4020A-M-2-TM

DATATAPE®

4020A MAGNETIC TAPE RECORD/REPRODUCE SYSTEM

SYSTEM MANUAL

BELL & HOWELL
DATATAPE DIVISION
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SECTION I

GENERAL DESCRIPTION

1-1. GENERAL.

1-2. The 4020A Magnetic Tape Record/Reproduce System is a compact, portable, or rackmounted, multitrack record/reproduce system using all solid-state electronics for recording and reproducing data on magnetic tape. The system uses either direct or FM record/reproduce electronics which may be mixed to suit the requirements of the application. The system may be operated on 115, 200, 240, or 260 Vac with a line frequency between 47 and 63 Hz, or between 380 and 420 Hz.

1-3. Figure 1-1 illustrates a typical 4020A system. The transport operates at nine bidirectional speeds from 15/32 ips to 120 ips and uses 1/2-inch or 1-inch-wide tape on 10-1/2 inch diameter instrumentation reels. The all-metal-surface magnetic heads have a 1000 hour life guarantee and are easily replaced. The system is completely self-contained, with the plug-in record/reproduce electronics readily accessible.

1-4. The data signal input and output connections to the system are normally made via BNC connectors on the front panel of each record and reproduce amplifier. The direct record/reproduce and FM record electronics are electrically switched for tape speeds. The FM reproduce electronics are electrically switchable for any two tape speeds or nine tape speeds depending on the type of reproduce amplifier used.

1-5. A switchable monitor meter is available for each set of seven record/reproduce amplifiers. Provision is also made for optional single channel voice logging, tape servo control, remote control assembly, and plug-in FM calibrator. Table 1-1 lists the major components and accessories for the 4020A system.

1-6. The Bell & Howell identification plate and serial number are located under one of the transport handles.

1-7. SYSTEM SPECIFICATIONS.

1-8. The typical performance characteristics for the 4020A Magnetic Tape Record/Reproduce System are listed in table 1-2. The characteristics are predicated on the use of Bell & Howell recommended magnetic tape and testing in accordance with Bell & Howell test procedures. The use of other than Bell & Howell test procedures or the recommended magnetic tape may result in degradation of optimum performance.

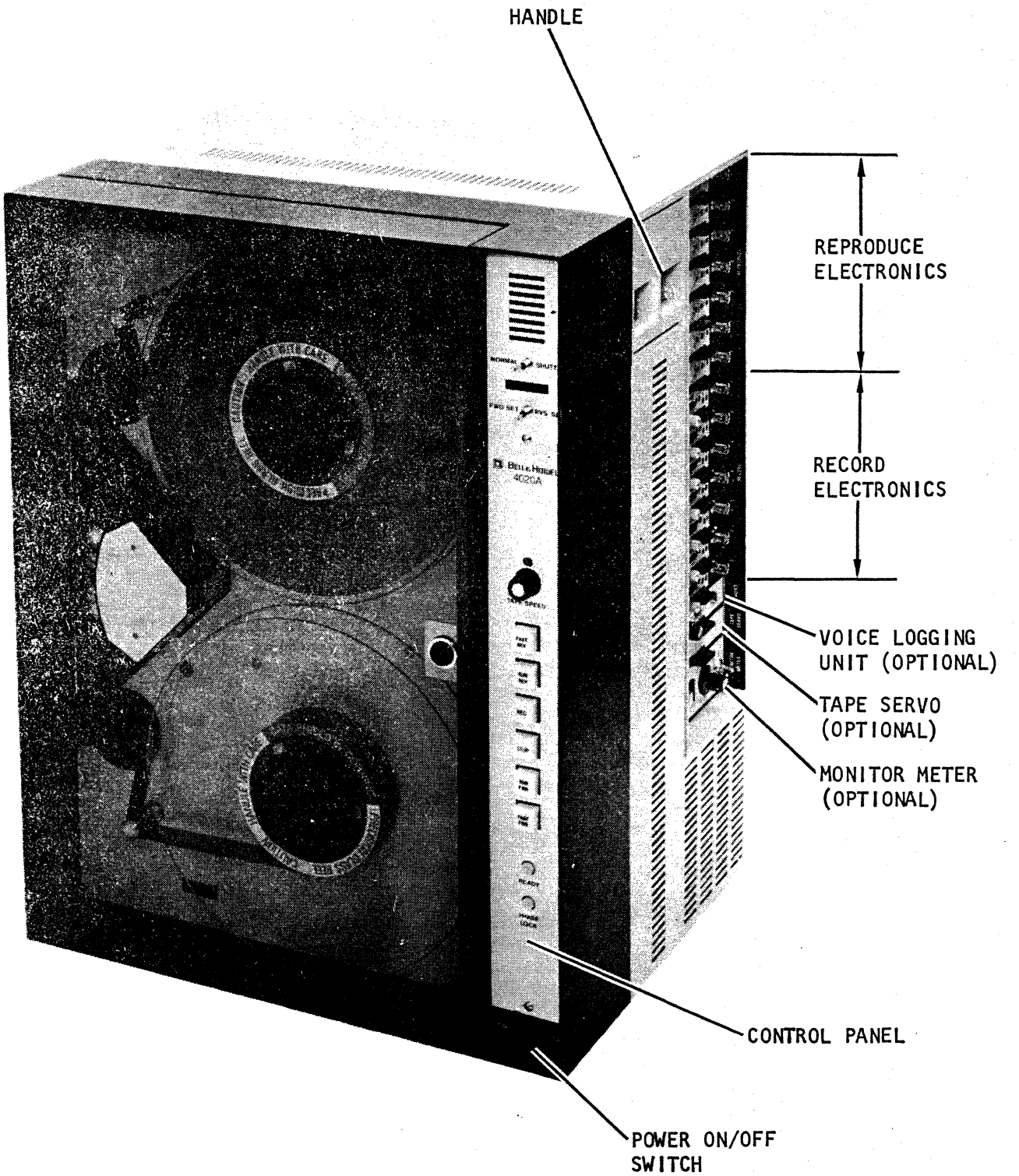


Figure 1-1. Typical 4020A System

ITEM	B&H TYPE NO.	REMARKS
Tape Transport	12-401D	Contains the capstan and reel motors, servo and control electronics, direction and tension sensors, power supply, and reproduce preamplifiers.
AC Power Supply	12-469-1	This power supply assembly provides all the operating dc voltage requirements for the transport motors, control circuits, and signal electronics. The input voltages may be 115, 200, 240, or 260 Vac at either frequency range of 47-63 Hz or 380-420 Hz (fan change required).
Amplifier Case	12-405A	Houses up to seven record and seven reproduce amplifiers. Also has provisions for monitor meter, tape lock, voice logging unit plug-ins.
1/2-Inch Head Assembly, Wide Band	12-418-1	Seven-track record and reproduce head assembly for 400 Hz to 1 MHz response. Includes edge track A.
1/2-Inch Head Assembly, Intermediate Band	12-418	Seven-track record and reproduce head assembly for 100 Hz to 300 kHz response. Includes edge track A.
1-Inch Head Assembly, Wide Band	12-428-1	Fourteen-track record and reproduce head assembly for 400 Hz to 1 MHz response. Includes edge tracks A and B.
1-Inch Head Assembly, Intermediate Band	12-428	Fourteen-track record and reproduce head assembly for 100 Hz to 300 kHz response. Includes edge tracks A and B.
Direct Record Amplifier	12-442-2	Seven-speed amplifiers for both intermediate band and wide band operation.
Direct Reproduce Amplifier	12-447C and 12-477C-1	Seven-speed reproduce amplifiers complete with phase and amplitude equalization for seven tape speeds and response of 100 Hz to 300 kHz and 400 Hz to 1 MHz, respectively.

Table 1-1. List of Major Components and Accessories for the 4020A System (Sheet 1 of 3)

ITEM	B&H TYPE NO.	REMARKS
FM Record Amplifier	12-454A	FM record amplifier for seven tape speeds.
FM Record Amplifier	12-454B	FM record amplifier for nine tape speeds.
FM Reproduce Amplifier	12-457G	FM reproduce amplifier for seven tape speeds. Accommodates any two of nine output filters, IB, WBI, and extended WB.
FM Reproduce Amplifier	12-457C	FM reproduce amplifier for nine tape speeds. Includes nine output filters, IB, WBI, and extended WB.
FM Reproduce Amplifier	12-458	FM reproduce amplifier for eight tape speeds. Accommodates LB, IB, and WBI.
Monitor Meter Assembly (Accessory)	12-443	Monitors any one of the record/reproduce amplifiers and indicates 0 dB as normal operating level.
Voice Logging Unit (Accessory)	12-478C-2	Records and reproduces voice commentary.
Remote Control Assembly (Accessory)	12-487B-1	Provides means of selecting tape speed and operating modes from a remote location. Includes remote footage counter.
Tape Lock Servo (Accessory)	12-471	This accessory consists of a tape lock decision circuit which permits the capstan speed to be controlled by a prerecorded reference frequency. This accessory utilizes direct record/reproduce electronics which may be placed in any channel position. Connections to the record/reproduce amplifiers are made via front panel BNC connectors. The accessory mounts in the second position of an amplifier mounting case.

Table 1-1. List of Major Components and Accessories for the 4020A System (Sheet 2 of 3)

ITEM	B&H TYPE NO.	REMARKS
Bin Loop Adapter (Accessory)	12-483	This accessory permits operation with a continuous loop of tape between 6 and 50 feet in length. Tape usage good for up to 2000 passes.
Plug-in FM Calibrator (Accessory)	12-455	This accessory plugs into the amplifier case and permits the accurate adjustment of the FM record/reproduce electronics to within 0.1 percent.
Rackmounting Kit (Accessory)	12-480-1	This accessory permits the 4020A to be slide-mounted in a standard EIA rack.
Rackmounting Kit (Accessory)	12-480-2	This accessory permits the 4020A to be fix-mounted in a standard EIA rack.

Table 1-1. List of Major Components and Accessories for the 4020A System (Sheet 3 of 3)

ITEM	CHARACTERISTIC
TAPE TRANSPORT	
Tape Speeds	Nine bidirectional speeds, rotary switch selectable 120, 60, 30, 15, 7-1/2, 3-3/4, 1-7/8, 15/16, and 15/32 ips (304.80, 152.40, 76.20, 38.10, 19.05, 9.52, 4.76, 2.38, and 1.19 cmps).
Reels	Standard EIA reels, 10-1/2 inches (26.67 cm) diameter, are accommodated. System specifications are established using Bell & Howell recommended precision reels.
Tape	Half-inch or 1-inch (1.27 or 2.54 cm) width standard, 1 or 1-1/2 mil (0.0254 or 0.0318 mm) thick.
Start Time	Ten seconds maximum at 120 ips (304.80 cmps) to phase lock. Less at lower speeds.
Stop Time	Four seconds or less at 120 ips (304.80 cmps).
Fast Forward/Reverse	3600 feet (1,097 m) in 6 minutes (nominal).
Tape Speed Accuracy	Tachometer mode within ±0.15% at all speeds. Tape mode within ±0.05% at all speeds. Capstan rotational accuracy within 0.01% in tachometer mode.
Fail Safe	Transport is brought to a safe stop without damage or spillage of tape. In all modes including power outage.
End-of-Tape	Automatic stop at either end of tape is provided by digital control logic and the capstan tachometer.
Record Transfer	Record transfer to a standby 4020A is provided at near-end-of-tape.
LED Footage Counter	Resettable 5-digit bidirectional counter that counts tape usage in feet or meters (depending on jumper selection).
Record Test	Provides for adjusting Direct and FM input signal levels without moving tape.
Record/Reproduce Test	Provides for adjusting FM reproduce electronics without moving tape.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 1 of 12)

ITEM	CHARACTERISTIC

Flutter (Cumulative, measured per IRIG 106-71)

Tape Speed (ips)	Tape Speed (cmps)	Flutter Bandwidth	% Flutter P-P (2 Sigma)
120	(304.80)	0.2 to 10,000 Hz	0.25
60	(152.40)	0.2 to 10,000 Hz	0.25
30	(76.20)	0.2 to 5,000 Hz	0.25
15	(38.10)	0.2 to 2,500 Hz	0.30
7-1/2	(19.05)	0.2 to 1,250 Hz	0.40
3-3/4	(9.52)	0.2 to 625 Hz	0.45
1-7/8	(4.76)	0.2 to 312 Hz	0.50
15/16	(2.38)	0.2 to 312 Hz	0.60
15/32	(1.19)	0.2 to 156 Hz	0.80

Static Skew

Adjustable to less than ±1 microsecond between outside tracks on a single 1-inch head stack at 60 ips.

Dynamic Skew

Tape Speed (ips)	Tape Speed (cmps)	Microseconds (1) P-P	(2) P-P	(3) P-P
120	(304.80)	0.4	1.0	2.0
60	(152.40)	0.8	2.0	4.0
30	(76.20)	1.6	4.0	8.0
15	(38.10)	3.2	8.0	16.0
7-1/2	(19.05)	6.4	16.0	32.0
3-3/4	(9.52)	12.8	32.0	64.0
1-7/8	(4.76)	25.6	64.0	128.0
15/16	(2.38)	52.0	128.0	256.0
15/32	(1.19)	104.0	256.0	512.0

(1) Track to adjacent track in same head stack
(2) Between outside tracks in same 1/2-inch head stack.
(3) Between outside tracks in same 1-inch head stack.

Controls

Backlighted pushbutton switches are provided for stop, run forward, run reverse, record, fast forward, and fast reverse. A rotary switch is provided for speed selection. For power on and tach-tape phase lock selection,

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 2 of 12)

ITEM	CHARACTERISTIC
	toggle switches are provided. Power on is indicated by illumination of speed selector. The following functions can be selected remotely: Speed Selection — Run Forward Record — Run Reverse Fast Reverse — Stop Fast Forward — Shuttle The speed is selected from the tape transport. All local transport tape motion controls are disabled in the "Remote" mode.
PHYSICAL ENVIRONMENT	
Temperature	Operating 0° to 50°C Storage -40° to 70°C without tape
Altitude	Operating at 20,000 feet (6,000 m) Storage to 30,000 feet (9,000 m)
Relative Humidity	5% to 95% without condensation
PHYSICAL DATA	
	Portable configuration.
Size	Dimensions: 17" (43.18 cm) W x 23" (58.52 cm) H x 13-5/8" (34.6 cm) D.
Weight	Approximately 120 lbs (54 kg). 14-channel system including power supply but not including reels.
Power	230 V rms ±10%; 115 V rms ±10%, 47 to 63 Hz; fan change required for 400 Hz operation; approximately 500 watts for 14-track record/reproduce system.
PHASE LOCK SERVO DRIVE	The phase lock capstan control provides closed loop servo operation for the dc capstan motor. This unit provides two modes of operation, tachometer and tape. In the tachometer mode, the control loop is established from the optical

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 3 of 12)

ITEM	CHARACTERISTIC
	disc on the capstan drive assembly; the tachometer mode is used for recording. The tape control servo mode uses a prerecorded signal from the tape to establish highly accurate speeds and low time base error. Capstan control is automatically returned to tachometer mode whenever the tape reference signal is lost, or when the system is placed in the record mode, regardless of position of the mode selector switch. Respective tachometer and tape lamps light only when transport is up to speed and in servo locked operation.
Time Base Error	
MAGNETIC HEADS	The record and reproduce head stacks are precision mounted on a single plug-in assembly for easy replacement.
Head and Head Stack Configuration	Per IRIG 106-73
Head Polarity	Per IRIG 106-73
Head Azimuth	Record head, factory set to better than ±1 minute of arc. Reproduce head adjustable.
Head Life	In excess of 1000 hours using Bell & Howell recommended tape.

Tape Speed (ips)	Tape Speed (cmps)	Control Reference (kHz)	TBE (μsec)
120	(304.80)	200	--
60	(152.40)	100	±1.0
30	(76.20)	50	±1.0
15	(38.10)	25	±2.0
7-1/2	(19.05)	12.5	±3.0
3-3/4	(9.52)	6.25	±4.0
1-7/8	(4.76)	3.125	±8.0
15/16	(2.38)	1.5625	±12.0
15/32	(1.19)	0.78125	--

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 4 of 12)

ITEM	CHARACTERISTIC
	(All the following data applies to 7 and 14 track configurations only.)
DIRECT RECORD/REPRODUCE	
Input Level	0.5 to 20 V peak-to-peak for normal record level. Maximum power level is 0.5 watt.
Input Impedance	75 ohms ±5% shunted by 50 picofarads maximum. When the input terminating resistor is removed, the input impedance shall be 20 K ohms minimum shunted by 50 picofarads maximum.
Output Level	0 to 4 V peak-to-peak into 600 ohms, single ended.
Output Impedance	Less than 75 ohms.
Equalization	Each reproduce amplifier incorporates seven equalizers, electrically selected by the speed control switch.
Frequency Response/SNR	

Tape Speed (ips)	Tape Speed (cmps)	Bandwidth (Hz + 3 dB)	SNR* (dB)	Bandwidth (kHz +3 dB)	SNR* (dB)
60	(152.40)	300 - 300,000	40	400 - 1000	25
30	(76.20)	200 - 150,000	40	400 - 500	25
15	(38.10)	100 - 75,000	39	400 - 250	24
7-1/2	(19.05)	100 - 37,500	37	400 - 125	23
3-3/4	(9.52)	100 - 18,200	35	400 - 62.5	22
1-7/8	(4.76)	100 - 9,300	33	400 - 31.25	22
15/16	(2.38)	100 - 4,650	31	400 - 16.623	22

*Measured at the output of an 18 dB filter per IRIG 106-75.

FM RECORD/REPRODUCE	
FM RECORD AMPLIFIER (9-speed)	Incorporates nine center frequencies, electrically selected by the speed control switch and pin jumper on each record amplifier.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 5 of 12)

ITEM	CHARACTERISTIC
Input Level	0.5 to 10 V peak-to-peak for ±40% deviation.
Input Impedance	20 K ohms single ended shunted by 20 picofarads maximum.
UNIVERSAL FM RECORD AMPLIFIER (9-speed)	
Input Voltage Selection Switch	A ten-position switch located on the front panel of each record amplifier allows for selection of the following calibrated input levels and operational modes: ±0.1 V ±0.2 V ±0.5 V ±1.0 V ±1.41 V ±2.0 V ±5.0 V Off (Record Inhibit) 0 (CF) (Center Frequency Calibration) Δ F (40% Deviation Calibration) Calibration of the above input levels is ±0.5%. The calibrated switch settings are augmented with a variable attenuator which allows for adjustment (uncalibrated) for input levels up to ±10 V. The variable attenuator is detented in the calibrated position.
Input Single Ended to Ground	Input Impedance 1 Megohm Input Protection ±20 V
Carrier Offset	To utilize the total range of a wholly positive, or wholly negative signal, the center frequency can be offset ±40% via an internal adjustment.
Output Level	The record head current is adjustable between 0 and 50 mA peak-to-peak.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 6 of 12)

ITEM	CHARACTERISTIC
Record Inhibit	In the OFF position of the front panel switch the record amplifier is isolated from the record head. However, power is applied to the VCO at all times power is applied to the system.
Calibration Indicator	Eight LED indicators meter the percentage of full scale input in the following manner:

Condition	Indication* and Color
Record Enable	1 Green
20% of Full Scale Input	1 - 2 Green
40% of Full Scale Input	1 - 3 Green
60% of Full Scale Input	1 - 4 Green
80% of Full Scale Input	1 - 5 Green
100% of Full Scale Input**	1 - 6 Green
110% of Full Scale Input	1 - 7 Green/ Yellow
120% of Full Scale Input	1 - 8 Green/ Yellow/Red

*Numbered from bottom of column to top.
**Corresponds to 40% Deviation of VCO.
Accuracy of indicators is ±3%.

NOTE: The above indicators relate to input levels independent of carrier offset.

Internal Calibrated Voltage Source	Each amplifier includes an internal calibrated voltage source to calibrate the VCO. CF (0) position of the input voltage selector switch provides zero volts on the VCO. ΔF (+40%) position of the input voltage selector switch provides +5V on the VCO. The above can be used for recording calibration signals.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 7 of 12)

ITEM	CHARACTERISTIC
EXTENDED WIDE BAND FM REPRODUCE AMPLIFIER (2-speed)	Accepts any two of nine filter networks, electrically selected by the speed control switch. Filters are switch selectable for either flat frequency response or best transient response.
Squelch	Reproduce amplifier output is squelched to zero when transport is not in phase lock.
Output Level	0 to 4 V peak-to-peak into 600 ohms.
Output Impedence	Less than 30 ohms.
Linearity	±0.5% of full deviation from best straight line through zero.
System Drift	After a 10-minute warmup, ±0.5% of full deviation in 8 hours with temperature variation of 5°C in the operating range of 0° to 50°C.
Wide Band and Intermediate Band Selection	The Extended Wide Band Amplifier can be configured by pin jumper selection for IRIG Wide Band Group I or IRIG Intermediate Band.
15/32 ips Operation	The Extended Wide Band Amplifier can be configured for 15/32 ips (1.19 cmps) operation by pin jumpers located on each amplifier.
Frequency Response/SNR:	

Intermediate Band

Tape Speed (ips)	Tape Speed (cmps)	Center Frequency (kHz)	Bandwidth (Hz)	SNR (dB)
60	(152.40)	108	20,000	53
30	(76.20)	54	10,000	52
15	(38.10)	27	5,000	51
7-1/2	(19.05)	13.5	2,500	50
3-3/4	(9.52)	6.75	1,250	49
1-7/8	(4.76)	3.375	625	48
15/16	(2.38)	1.687	312	47

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 8 of 12)

ITEM	CHARACTERISTIC				
Wide Band Group I	Tape Speed (ips)	Tape Speed (cmps)	Center Frequency (kHz)	Bandwidth (Hz)	SNR (dB)
	60	(152.40)	216	40,000	51
	30	(76.20)	108	20,000	50
	15	(38.10)	54	10,000	49
	7-1/2	(19.05)	27	5,000	48
	3-3/4	(9.52)	13.5	2,500	47
	1-7/8	(4.76)	6.75	1,250	46
	15/16	(2.38)	3.375	625	45
	15/32	(1.19)	1.687	312	43
Extended Wide Band (Wide Band Heads)	60	(152.40)	432	80,000	48
	30	(76.20)	216	40,000	47
	15	(38.10)	108	20,000	46
	7-1/2	(19.05)	54	10,000	45
	3-3/4	(9.52)	27	5,000	44
	1-7/8	(4.76)	13.5	2,500	43
	15/16	(2.38)	6.75	1,250	42
Total Harmonic Distortion	Less than 1.5% for any frequency within the bandpass of 40 kHz - 312 kHz.				
UNIVERSAL FM REPRODUCE AMPLIFIER (8-speed)	Contains eight filter networks electrically selected for tape speeds of 60 ips (152.40 cmps) through 15/16 ips (2.38 cmps) by the transport rotary speed select switch or the remote speed select switch. Filters are switch selectable for Bessel or Butterworth response.				
Output Level and Impedance	The amplifier will provide 4 V peak-to-peak into 150 ohm load from an output impedance of less than 0.5 ohm. Coarse or fine adjustment of dc offset is provided.				
Flutter Correction	Provision is included for electronic flutter compensation by combining the data output with the output of an adjacent FM channel recorded with its input short-circuited to ground.				
Squelch	Reproduce amplifier output is squelched to zero when transport is not in phase lock.				

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 9 of 12)

ITEM	CHARACTERISTIC

Frequency Response/ SNR Universal Amplifier:

Intermediate Band

Tape Speed (ips)	Tape Speed (cmps)	Center Frequency (kHz)	Bandwidth (kHz)	SNR (dB)
60	(152.40)	108	DC to 20	49
30	(76.20)	54	DC to 10	48
15	(38.10)	27	DC to 5	47
7-1/2	(19.05)	13.5	DC to 2.5	46
3-3/4	(9.52)	6.75	DC to 1.25	45
1-7/8	(4.76)	3.375	DC to 0.625	42
15/16	(2.38)	1.687	DC to 0.312	40

Wide Band Group I

60	(152.40)	216	DC to 40	48
30	(76.20)	108	DC to 20	47
15	(38.10)	54	DC to 10	46
7-1/2	(19.05)	27	DC to 5	45
3-3/4	(9.52)	13.5	DC to 2.5	44
1-7/8	(4.76)	6.75	DC to 1.25	41
15/16	(2.38)	3.375	DC to 0.625	41

Total Harmonic Distortion: Less than 1.5% for any frequency within the band-pass of 40 kHz-312 kHz.

UNIVERSAL FM REPRODUCE AMPLIFIER (9-speed)

Output Level: 4 V peak-to-peak with a minimum load of 150 ohms.

Output Impedance: Less than 0.6 ohm.

DC Offset: ±2 V (coarse and fine adjustment).

Squelch: Activated when not in tach or tape servo lock.

Filter Characteristic: Approximated Butterworth or Bessel Characteristic switch selectable.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 10 of 12)

ITEM	CHARACTERISTIC			
Frequency Response and SNR (Reproduce Mode)				
Intermediate Band (IB or WB Heads)	Tape Speed (ips)	Bandwidth (kHz ±0.5 dB)	Center Frequency (kHz)	SNR* (dB)
	120	0 to 40	216	50
	60	0 to 20	108	50
	30	0 to 10	54	49
	15	0 to 5	27	48
	7.5	0 to 2.5	13.5	47
	3.75	0 to 1.25	6.75	46
	1.875	0 to 0.625	3.375	45
	0.9375	0 to 0.312	1.687	43
Wide Band Group I (IB or WB Heads)	Tape Speed (ips)	Bandwidth (kHz ±0.5 dB)	Center Frequency (kHz)	SNR* (dB)
	120	0 to 80	432	49
	60	0 to 40	216	49
	30	0 to 20	108	48
	15	0 to 10	54	47
	7.5	0 to 5	27	46
	3.75	0 to 2.5	13.5	45
	1.875	0 to 1.25	6.75	44
	0.937	0 to 0.625	3.375	43
	0.4687	0 to 0.312	1.687	42
Extended Wide Band (WB Heads Only)	Tape Speed (ips)	Bandwidth (kHz ±0.5 dB)	Center Frequency (kHz)	SNR* (dB)
	60	0 to 80	432	48
	30	0 to 40	216	47
	15	0 to 20	108	46
	7.5	0 to 10	54	46
	3.75	0 to 5	27	44
	1.875	0 to 2.5	13.5	44
	0.9375	0 to 1.25	6.75	42
	0.4687	0 to 0.625	3.375	40

*Preliminary Specifications

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 11 of 12)

ITEM	CHARACTERISTIC
Harmonic Distortion	Less than 1.5% total at all tape speeds.
Linearity	±0.5% of full deviation from best straight line through zero.
System Drift	After a 10-minute warmup: ±0.5% of full deviation in 8 hours with temperature variation of 20°C.

Table 1-2. Typical Performance Characteristics for the 4020A System (Sheet 12 of 12)

SECTION II

INSTALLATION

2-1. GENERAL.

2-2. The 4020A system is completely self-contained and ready for operation after it has been unpacked and installed. Ensure that the position of the power supply jumper board corresponds to the operating line voltage. The jumper board is located on the end of the power supply opposite the fan. Markings denote each position.

2-3. UNPACKING.

2-4. Set the shipping container in the area in which it is to be unpacked. Keep it upright as marked and carefully remove the shipping container. When free of the shipping container, set the system down gently in an upright position and carefully inspect it for any possible damage incurred during shipment. Report any damage to your nearest Bell & Howell DATATAPE Division representative.

2-5. NORMAL INSTALLATION.

CAUTION

The system should be turned OFF before removing or replacing any components in the system.

2-6. Normal installation consists of setting the system in a suitable position on a bench, table, cart, etc., or installing it in a rack which will provide adequate support and sufficient space. (See figure 2-1 for weight and dimensions.) Be sure to allow sufficient clearance for access to the signal electronics and for proper ventilation.

NOTE

The system should be located in an area free from strong electrical or magnetic fields and have an ample supply of ambient air.

2-7. POWER. The system is capable of operating on either 115, 200, 220, 240, or 260 Vac by changing the position of a jumper board on the power supply. To gain access to this jumper board it is necessary to remove the left side cover of the transport. The cover is held in place by four screws which are located in the bottom side of the transport and beneath the left carrying handle. Once the cover is removed, the jumper board is visible at the lower left side of the transport. A cutout in the jumper board allows the selected voltage decal to be seen. To change voltages, first make sure power is disconnected from the transport, then remove the two screws holding the jumper board in place and move the board to the desired position. Replace the two screws in the board and replace

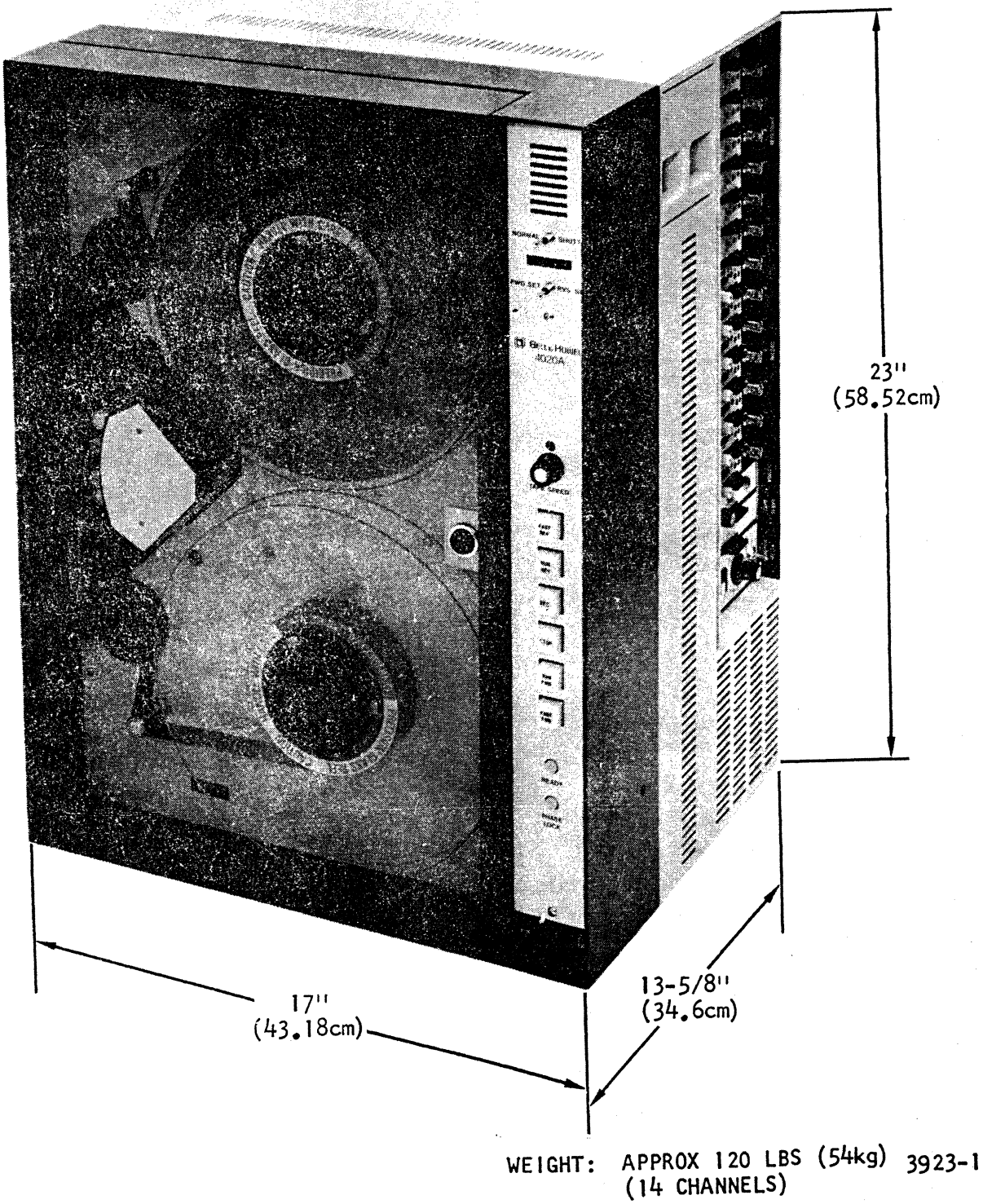


Figure 2-1. Portable System Dimensions

the side cover on the transport. Primary power protection is provided by two 10 ampere slo-blow fuses installed in the lower right-hand corner of the transport. Connect the system to a suitable power source. The power cable supplied with the system has a standard twist-lock connector on one end which mates with the power input connector on the side of the cabinet (A1J2). The power ON/OFF switch is located at the bottom of the transport control panel. When this switch is in the ON position, all operating ac and dc voltages are applied to the system. The speed indicator light, behind the TAPE SPEED SELECTOR switch, illuminates when the power switch is ON and power is applied.

2-8. HEAD CONNECTIONS. Ensure that all mating plugs and connectors are firmly seated. The record heads are connected to the amplifier mother board assembly by connector A2J22A for a 7-channel system, or A2J22A and A2J22B for a 14-channel system. The reproduce heads are connected to the preamplifier assembly by way of connector A1J22C for both 7- and 14-channel systems. The output of the preamplifiers are connected to the amplifier mother board by way of connectors A2J20A and A2J20B, and A2J21A and A2J21B. Figure 7-6 of the transport manual illustrates the interconnections between the heads, the preamplifiers, and the amplifier mother board assembly.

2-9. RECORD/REPRODUCE AMPLIFIER CONNECTIONS. All internal system connections are complete when the record/reproduce amplifiers are firmly seated in their proper positions. External signal input/output connections to the record/reproduce amplifiers are normally made via front panel BNC connectors. Additional BNC connectors are provided with the optional slide rackmounting kit for mounting at the rear of the system.

2-10. ACCESSORY CONNECTIONS.

2-11. REMOTE CONTROL CONNECTIONS. If a remote control unit is to be used, plug the remote control cable into connector A1J7 located on the side of the cabinet. The remote control unit will control the operating modes and tape speed of the system when the TAPE SPEED SELECTOR switch is in the REMOTE position. The operating mode will be indicated by the backlighted pushbuttons on the control panel.

2-12. OVERLAP CONNECTION. The system is designed to provide an overlap transfer to another system. The transfer function is accomplished by interconnecting the transports to each other via the remote control connector A1J7. More than two systems may be interconnected and the transfer function can be continuous. However, each system must be reloaded with fresh tape after it has transferred the recording to the next system. Figure 2-2 shows the interconnecting wiring diagram for continuous transfer between two or three systems. For a one-way transfer (that is, from a master to a slave), omit the pair of wires between pins R and Q of transport no. 1, and pins J and S of transport no. 2.

2-13. TAPE SERVO CONTROL CONNECTION. This optional accessory plugs into an amplifier case and all internal system connections are complete when the accessory is installed in the second position. Two front panel BNC connectors accommodate the connections between the tape servo control accessory and the direct record/reproduce amplifiers. To record a servo reference signal, connect the record cable between the tape servo control and a direct record amplifier. Likewise in the

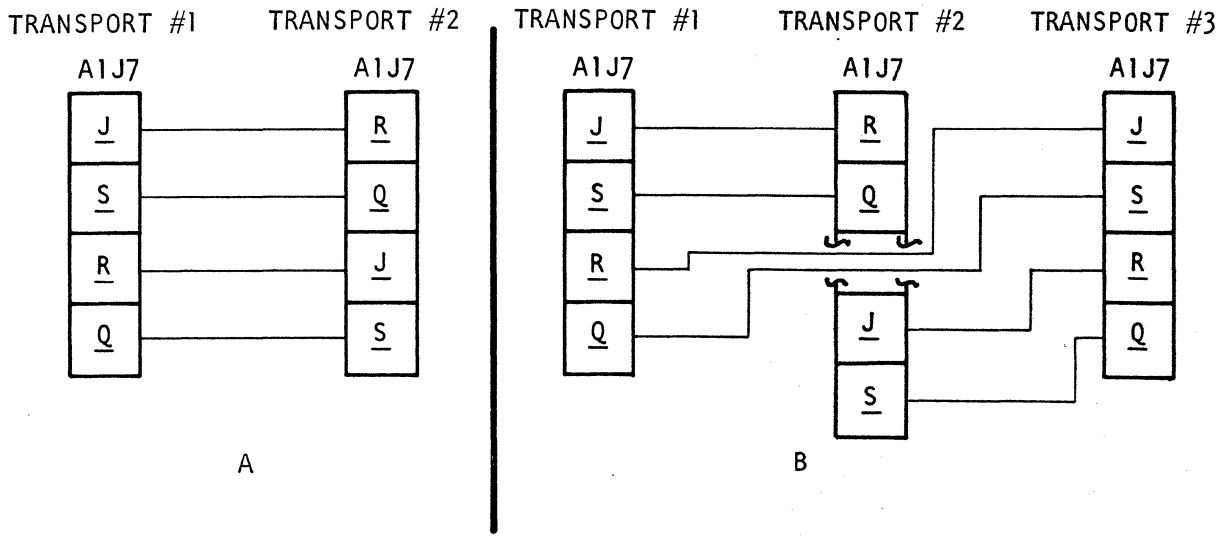


Figure 2-2. Wiring Diagram, Continuous Overlap Transfer; A: Two Transports; B: Three Transports

reproduce TAPE lock mode, connect the reproduce cable between the tape servo control and the direct reproduce amplifier of the channel which has the tape servo frequency. Mode selection is made by a toggle switch mounted on the front panel of the tape servo control accessory. Illumination of the tape lock lamp on the front panel of the accessory indicates TAPE PHASE LOCK has been achieved.

2-14. BIN LOOP ADAPTER CONNECTION. A bin loop adapter is available for use with the system in either the 1/2-inch or 1-inch versions. The accessory is easily mounted on transports with predrilled mounting holes on their base plate. The bin loop adapter will handle tape loops between 6 feet and 50 feet. Under normal operating conditions, up to 2000 passes may be achieved from one loop of tape. Installation and operation instructions for the bin loop adapter are contained in the bin loop adapter component manual, Bell & Howell part number 992656.

2-15. PLUG-IN FM CALIBRATOR. A plug-in FM calibrator is available for use with the 4020A system. When used, the plug-in FM calibrator occupies the space in the amplifier case where the monitor meter is normally installed. Once plugged in, all internal system connections are completed.

2-16. MONITOR METER ASSEMBLY. The monitor meter circuit board is positioned by guide slots in the first position below the record/reproduce amplifiers in the amplifier case. When installed in the proper position, all electrical connections are completed. To monitor channels 1 through 7, the monitor meter is installed in the right side of the amplifier case. To monitor channels 8 through 14 in a 14-channel system, a second monitor meter is installed in the left side of the amplifier case.

2-17. VOICE LOGGING UNIT CONNECTION. The 12-478C-2 Voice Logging Unit is optionally furnished installed in the 4020A system, ready for operation. However, the components are available as a kit which may be installed in the field. The installation procedures for the voice logging unit are contained in the voice logging unit component manual.

2-18. ENERGIZING THE SYSTEM.

2-19. After the system has been installed and the power and signal connections have been made, the system may be energized by operating the power ON/OFF switch. Check all modes of operation (see Section III). In the event of a malfunction, check the $\pm$18, $\pm$15, and $\pm$5 volt power supplies at the indicated terminals on the power supply unit.

SECTION III

OPERATION

3-1. GENERAL.

3-2. The performance of the 4020A is carefully checked at the factory before shipment. The system may be placed in service immediately after being installed as described in Section II of this manual.

3-3. Personnel unfamiliar with the equipment should read all the component manuals for the overall system. Personnel familiar with systems of this same general type should read the transport manual and be familiar with the transport controls and interlocks before attempting operation of the system.

3-4. ACCESS TO CONTROLS. All controls for normal operation of the system are accessible from the front and sides. Detailed descriptions of the controls and indicators are contained in the paragraphs below.

3-5. CONTROLS AND INDICATORS.

3-6. The operating modes of RUN FORWARD, RUN REVERSE, RECORD, FAST FORWARD, FAST REVERSE, and STOP are selected by backlighted pushbutton switches. Speed selection is by a backlighted rotary switch. Two indicator lights on the front control panel are for PHASE LOCK and READY. Table 3-1 lists and describes the controls and indicators and their function.

ITEM	FUNCTION
POWER (ON/OFF)	Rocker switch at the bottom of the control panel. This switch applies ac power to the transport.
TAPE SPEED SELECTOR	Ten-position rotary switch. Selects 15/32 ips to 120 ips speed and remote (R) operation.
RECORD	Momentary action backlighted switch. Press the RECORD and either RUN FWD or RUN REV switches simultaneously, then release the RUN switch before releasing the RECORD switch. The record indicator is illuminated in the record mode or when the RECORD TEST switch is in the ON position.
RUN FWD	Momentary action backlighted switch. Press this switch to initiate tape motion at the selected speed from the supply reel to the takeup reel. In the RECORD mode, pressing this button will turn off the record electronics. The indicator lights when the transport is in RUN FWD.

Table 3-1. Controls and Indicators, 4020A Magnetic Tape System (Sheet 1 of 4)

ITEM	FUNCTION
RUN REV	Momentary action backlighted switch. Press this switch to initiate tape motion at the selected tape speed from the takeup reel to the supply reel. The indicator lights when the transport is in RUN REV.
FAST REV	Momentary action backlighted switch. Press this button to rewind the tape at 120 ips; tape speed is capstan controlled. After the EOT sensor stops the FAST REV or RUN REV mode, pressing this switch again allows the tape to be completely rewound onto the supply reel.
FAST FWD	Momentary action backlighted switch. Press this button to wind the tape at 120 ips; tape speed is capstan controlled. After the EOT sensor stops the FAST FWD or RUN FWD mode, pressing this switch again allows the tape to be completely wound onto the takeup reel.
STOP (READY)	Momentary action backlighted switch. Press this button to stop tape motion from any mode. To change operating modes, say from RUN REV to FAST FWD, going through stop is automatic, thus eliminating the need for pressing the STOP button when changing modes. This switch illuminates only in the STOP and READY modes.
READY Indicator	Indicator lamp. Illuminates when tape is threaded, the supply and takeup tension is proper, and power is on. The READY lamp is interlocked with the RECORD TEST switch so that it may NOT be illuminated when this switch is in the TEST position. The ready light will remain on in any operating mode, indicating that any other mode may be selected.
PHASE LOCK Indicator	Indicator lamp. Illuminates when the capstan is in phase lock in either the TACH or TAPE mode. If the optional tape servo control accessory is used, both this indicator and the indicator mounted on the tape servo control accessory must be illuminated to indicate TAPE MODE PHASE LOCK. In the TACH mode, only the PHASE LOCK indicator on the control panel will illuminate when the capstan is at the selected speed.
TIME ELAPSED Meter	Located on transport plate cover. Indicates recorder operating time.
RECORD TEST Switch	This switch is located on the monitor meter plug-in assembly. In the ON position, this switch energizes the direct

Table 3-1. Controls and Indicators, 4020A Magnetic Tape System (Sheet 2 of 4)

ITEM	FUNCTION
	record amplifiers, and the FM record and reproduce amplifiers, and interlocks the transport so that it will not operate in any mode. The ON position also causes the RECORD indicator to illuminate which, when illuminated and with no tape motion, warns the operator that the RECORD TEST switch is in the ON position.
REMOTE	TAPE SPEED SELECT switch which selects the REMOTE mode of operation in position R.
LED FOOTAGE COUNTER	Located on the front control panel. Indicates tape footage on LED display (in feet or meters), passing the capstan, forward or backward, from any starting point.
NORMAL Switch Selection	Located above the LED display. Operator selection of this mode of operation results in his complete control of recorder operation.
SHUTTLE Switch Selection	Located above the LED display. Operator selection of this mode of operation results in his control of recorder operation, however, the recorder will run tape between zero and target number automatically.
FORWARD SET Momentary Switch	Located below the LED display. Holding this switch momentarily, the operator sets tape count to zero. LED display indicates 0000.0.
REVERSE SET Momentary Switch	Located below the LED display. Holding this switch momentarily, the operator sets the tape reversal point. Recorder will start if not operating, and run tape in reverse.
VOLUME CONTROL	Mounted on the front panel of the voice logging unit, this controls the volume of the reproduce amplifier.
TAPE SERVO Indicator	Located on the front panel of the tape servo control unit, this light illuminates to indicate that the tape transport is in TAPE MODE PHASE LOCK.
TAPE/TACH Switch	Located on the front panel of the tape servo control unit, this switch selects either TAPE or TACH mode of operation for the capstan.

Table 3-1. Controls and Indicators, 4020A Magnetic Tape System (Sheet 3 of 4)

ITEM	FUNCTION
MONITOR METER	Mounted on the front panel of the Monitor Meter accessory. The meter indicates the record or reproduce signal level of the channel selected by the CHANNEL and RCD/REPRO switches.
CHANNEL Switch	Rotary switch on the front panel of the Monitor Meter accessory. Selects channels 1 through 7 or 8 through 14 to be monitored.
RCD/REPRO Switch	Selects record or reproduce signals for display on meter.

Table 3-1. Controls and Indicators, 4020A Magnetic Tape System (Sheet 4 of 4)

3-7. OPERATING PRECAUTIONS.

3-8. The following safeguards apply to this system, from which high accuracy and optimum operation are expected.

a. Magnetic Tape. Dirty tape or any which appears to be worn should be discarded as unreliable. Dust or dirt on the tape will lift it away from the heads and cause excessive tape dropouts. Excessively worn tape or tape with jagged or uneven edges may cause mistracking and loss of signal. The Model 4020A Recorder/Reproducer requires either of two types of magnetic tape (or their equivalents): 3M 801 is recommended for Intermediate Band (300 kHz) applications and Ampex 797 is recommended for Wide Band (1 MHz) applications.

b. Tape Reels. The quality and condition of the tape reels used on any tape transport have a significant effect on the quality of tape recordings and reproductions. Excessive unbalance or misalignment of the reels may cause mistracking of the tape, or flutter, or both, resulting in degradation of the accuracy of recorded signals.

c. Dust and Dirt Accumulation. To avoid dust contamination to the magnetic tape and to the tape transport, leave the dust cover closed whenever possible. As periodic inspection indicates, the head stacks, the capstan, and the capstan pulleys should be cleaned. See the preventive maintenance procedures in the transport manual for the cleaning procedures.

NOTE

Cleaning the tape transport components is important. Most tape manufacturers coat their tapes with a lubricant which gradually forms a coating on components with which it comes in contact. A dirty capstan may cause loss of positive capstan control of the tape speed. Excessive oxide deposits on the head stacks are detrimental to close tape-to-head contact and may cause excessive tape dropouts as well as deterioration in the system high frequency response. Accumulation of dirt deposits on the capstan drive pulleys may adversely affect the accuracy of the tape speed.

d. Demagnetization. It is extremely important that tape transport components which come in contact with the tape, particularly the record and reproduce heads, do not become magnetized. Magnetized components degrade the system signal-to-noise ratio, cause excessive second harmonic distortion in recorded signals, and act to induce spurious flux fields into the magnetic tape. If the following precautions are observed, little difficulty should be encountered in this respect.

1. DO NOT install or remove amplifiers from their mounting assemblies while the power is on.

2. DO NOT saturate the record heads with abnormally high input signals or unbalanced pulses.

3. DO NOT connect an ohmmeter or any other dc measuring device or dc source across the head windings, for the presence of dc current will magnetize the heads and the dc current may be sufficient to damage the head windings.

4. DO NOT allow magnetized components to come in contact with the tape transport components.

5. DO NOT locate the equipment in strong electrical or magnetic fields.

6. As performance checks indicate, demagnetize the magnetic heads and any other applicable tape handling components.

3-9. SAFETY INTERLOCKS AND FUSES.

3-10. TENSION SWITCH. The transport will not operate in any mode until the tape is properly threaded and tape tension is established. The tension switches on both the supply and takeup sides will automatically stop the transport if the tape breaks, goes slack, or is run completely off either reel.

3-11. FAIL-SAFE MECHANICAL BRAKES. Power must be applied and the machine must be in a READY condition to release the mechanical brakes. Therefore, any power failure or loss of the READY condition will cause the fail-safe brakes to stop the supply and takeup reels.

3-12. FUSES. Two 10 ampere slo-blow fuses are located on the power supply.

3-13. INSTALLING TAPE REELS.

3-14. Install a tape reel on the hub assembly as follows:

a. Turn the knurled knob of the hub assembly counterclockwise. (This withdraws the three finger actuators into the hub assembly.)

b. Place the tape reel on the hub assembly and turn the knurled knob fully clockwise.

c. Inspect the three finger actuators to make certain that they are holding the tape reel firmly in place.

d. To remove the reel, turn the knob assembly counterclockwise and lift the tape reel by pulling evenly away from the hub assembly.

3-15. THREADING TAPE.

3-16. When threading tape, be sure that the oxide surface of the tape is against the magnetic heads. Threading is as follows:

a. Turn off the power and open the dust cover door.

b. Install the full reel of tape on the supply (upper) reel hub, and an empty reel on the takeup (lower) reel hub, following the procedures outlined in paragraph 3-14.

c. Unwind about 4 feet of tape from the supply reel and thread it as shown in figure 3-1.

d. When the tape is threaded as shown, hold the end against the takeup reel hub and rotate the takeup reel counterclockwise until the tape winds on itself and holds tight to the hub; then continue to rotate the takeup reel to take up any slack in the tape. Ensure that the tension sensors are positioned in the center of their travel.

e. Close the dust cover, turn on power, check the READY indicator, and, if it is illuminated, press the RUN FWD button and observe that the tape motion is smooth and proper. STOP the transport; it is now ready for operation.

3-17. The operation and maintenance manual for the bin loop adapter illustrates the tape threading path when the bin loop adapter is installed on the tape transport.

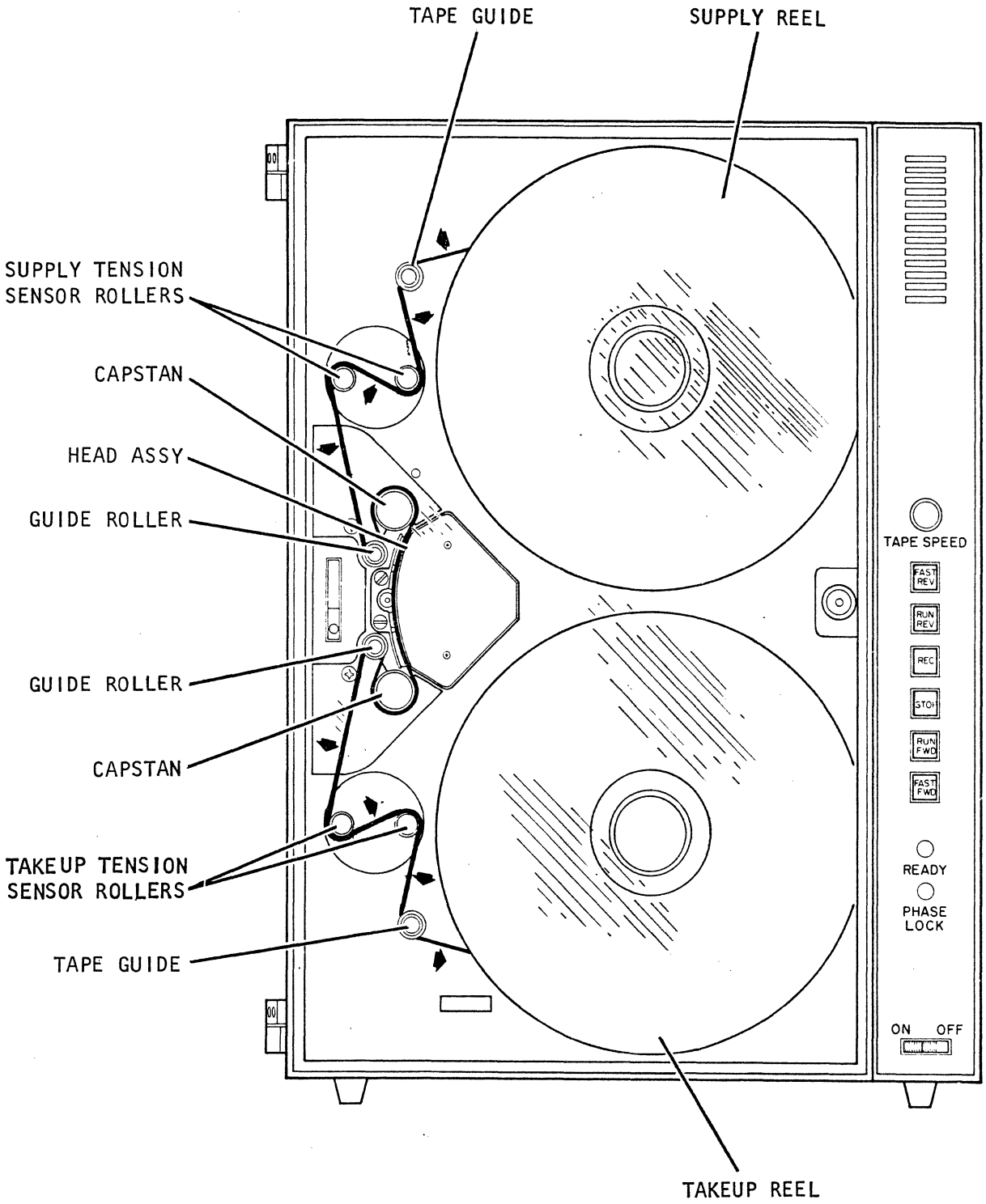


Figure 3-1. Tape Threading Path, Standard Transport

3-18. RECORDING DATA AND REPRODUCING DATA.

3-19. The procedures for recording and reproducing data are set forth in paragraph 3-20. It is understood that the tape transport is properly adjusted and the record and reproduce amplifiers have been properly calibrated. The calibration procedures for the transport are found in Section V of the transport manual, while the calibration procedures for the signal electronics are found in Section V of the system manual.

3-20. To record or reproduce data, proceed as follows:

a. Be sure that the optional RECORD TEST switch, located on the monitor meter, is set to the OFF position.

b. Turn system power ON.

c. Set the TAPE SPEED SELECTOR switch to the desired speed. In general, the transport should be operated at the lowest speed consistent with the frequency range of signals to be recorded and the recording technique used.

NOTE

To determine the running time for a given length of tape, divide the length of tape in feet by 5 times the tape speed in inches per second. For example, 2100 feet of tape will run for 7 minutes at 60 inches per second.

d. Place tape to be used on the supply (upper) reel hub and an empty reel on the takeup (lower) reel hub. (Before recording, the tape must be bulk-erased.)

e. Thread the tape following the path shown in figure 3-1.

f. Place the NORMAL/SHUTTLE switch to NORMAL for complete operator control. Placing the NORMAL/SHUTTLE switch to SHUTTLE will provide operator control; however, the recorder will run tape between zero and the target number automatically.

g. To reproduce data, press the RUN FWD or RUN REV pushbutton only. To record data, simultaneously press the RECORD and either the RUN FWD or RUN REV pushbutton, releasing the RECORD pushbutton last. The appropriate mode indicator lights will come on immediately, indicating that recording or reproducing is in progress.

h. To set the tape count to zero, hold the momentary toggle switch to FORWARD SET. The LED display will indicate 0000.0. In the SHUTTLE mode, this action sets the FORWARD SET position.

i. To set the tape reversal point in the SHUTTLE mode, hold the momentary toggle switch to REVERSE SET. If the recorder is not operating, it will start, and run tape in reverse.

j. To stop the recording or reproducing operation at any time, press the STOP button. During recording, pressing any other mode switch will stop the recording process.

k. The RUN mode is terminated by the END-OF-TAPE (EOT) sensor. However, if the overlap feature of the system is used, transfer to the standby system occurs about 50 feet ahead of EOT by the NEAR-END-OF-TAPE (NEOT) sensor.

3-21. RECORD LEVEL ADJUSTMENT.

3-22. Operation of the direct record amplifier consists of establishing the proper record level if the signal to be recorded is of a different level than previous calibration. To establish a new record level, follow the record level adjustment procedures in Section V of this manual.

3-23. REMOTE TRANSPORT OPERATION.

3-24. The 4020A system can be operated from a remote location by using the Bell & Howell 12-487B-1 Remote Control Assembly. In general, the operation of the record/reproduce system by remote control duplicates local operation of the system. All mode control switches and the speed selector switch are included with the remote control assembly. The exception is the main system power, which is turned on at the tape transport.

3-25. Control of the system is passed to the remote control assembly when the TAPE SPEED SELECT switch on the tape transport is in the remote (R) position. In this condition, the mode control switches on the tape transport are disabled.

3-26. REMOTE CONTROL OPERATION. The controls and indicators for the remote control assembly are listed in the Remote Control manual. The REMOTE READY indicator indicates that control has been passed to the remote control assembly, that tape is properly threaded on the transport, and that the RECORD TEST switch on the monitor meter is set to the OFF position.

3-27. When the REMOTE READY indicator is on, remote operation of the system is identical with local: tape speed is selected by rotating the remote tape speed selector to the desired speed; modes are selected by pressing the appropriate mode pushbutton. (To select the record mode, press the REC pushbutton simultaneously with the RUN FWD or RUN REV pushbutton, releasing the RUN pushbutton first.)

3-28. REMOTE FOOTAGE COUNTER AND SHUTTLE OPERATION. Remote operation of the tape footage counter is similar to that on the transport. The counter can be reset to zero by operating the RESET toggle at the counter. The counter will count up or down, depending on the direction of tape movement.

3-29. TAPE LOCK SERVO OPERATIONAL PROCEDURES.

3-30. Operation of the tape lock servo consists of selecting TAPE or TACH mode of operation.

3-31. TACH MODE. To operate in the TACH mode, proceed as follows:

a. Set the TACH/TAPE switch to the TACH position.

b. Operate the tape transport in accordance with operation instructions in paragraph 3-20.

c. The PHASE LOCK indicator on the tape transport control panel will be illuminated when the system is in TACH PHASE LOCK.

3-32. TAPE MODE. To operate in the TAPE mode, proceed as follows:

a. Prerecord a reference signal on tape. Connect a BNC cable from REC on the tape lock servo unit to a direct record amplifier.

b. Connect a BNC cable from the direct reproduce amplifier to REP on the tape lock servo unit.

c. Set the TACH/TAPE switch to TAPE.

d. When the capstan reaches speed and locks up on the reference signal, the TAPE SERVO indicator on the tape lock servo will illuminate and the PHASE LOCK indicator on the tape transport control panel will also illuminate.

3-33. In the event the reproduce reference signal is lost in the TAPE mode, the system will automatically go into TACH mode. When this happens, the TAPE SERVO indicator on the tape lock servo front panel will go out but the PHASE LOCK indicator on the tape transport control panel will remain illuminated.

3-34. MONITOR METER OPERATION PROCEDURES.

3-35. Operation of the monitor meter consists of selecting either record or reproduce signals to be monitored. This is done by placing the RCD/REPRO switch in the desired position and rotating the CHANNEL selector switch to the desired channel. By placing the RCD TEST switch in the ON position, the operator can operate the record and reproduce electronics without moving the tape. The OFF position of the RCD TEST switch has no effect on system operation.

3-36. VOICE LOGGING UNIT OPERATION PROCEDURES.

3-37. RECORDING.

CAUTION

A recording will be made in all modes of tape movement if the push-to-talk switch is actuated inadvertently.

3-38. A hand-held mobile type microphone with a five-foot cable is supplied with the voice logging unit. For operation, the phone plug on the microphone cable is inserted into the MIC jack on the front panel of the voice logging unit amplifier. The microphone has a push-to-talk momentary action switch. Pressing the switch button actuates a relay which connects the voice record electronics to the record head.

3-39. REPRODUCING.

3-40. Voice commentary will be reproduced in the run modes whenever the VOLUME control is advanced, providing the microphone button is not depressed. Normal reproduction is through the speaker assembly at the top of the transport control panel. Headphones may be plugged into the PHONES jack on the amplifier panel. The speaker is automatically disconnected when a plug is inserted in the PHONES jack.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL.

4-2. In operation, data signals are applied to the record amplifiers and, as dictated by the recording technique used, amplified and/or converted to the form required to drive the record head for recording of magnetic fields into the oxide coating on the magnetic tape. The recording magnetic fields vary according to the recording technique used. In direct recording, the fields are proportional in intensity (amplitude of the data) and change at a rate equal to the frequency of the data signal. In FM recording, the amplitude of the data signal determines the percentage of deviation from center frequency, and, consequently, the recorded wavelength as well. The frequency of the data signal determines the rate at which the deviation changes.

4-3. The magnetization impressed on the tape by the recording process is used to reproduce the recorded signal by passing the tape over a reproduce head. The magnetization of the tape produces flux changes in the core of the reproduce head, and as this flux changes, a voltage is induced in the head windings. The output voltage from the reproduce head is proportional to the rate of change of flux and not the flux itself. Thus, the reproduce head acts as a differentiator, and the signal recovered is actually the derivative of the recorded signal rather than the signal itself. It is this signal which is applied to the preamplifier and the reproduce amplifier where it is restored to its original form.

4-4. TAPE TRANSPORT.

4-5. The 12-401D Tape Transport utilizes a constant-tension tape drive to move magnetic tape at precisely controlled tape speeds without using pinch rollers. The tape drive consists of dual capstans driven through a common belt by a high torque, servo controlled dc motor. The magnetic head stacks mount between the dual capstans. The dual capstans isolate the head section of tape from disturbances outside the capstan drive.

4-6. The tape transport operates at nine bidirectional speeds. The system uses 10-1/2-inch-diameter instrumentation tape reels. It handles 1/2-inch or 1-inch-wide mylar-based magnetic tape of 1 mil or 1.5 mil thickness. The head stacks are all-metal-surface units which provide long life usage. Electrical connections to the heads are made through receptacles on the transport. All input/output connections are normally made at BNC connectors on the front panel of each record/reproduce amplifier.

4-7. The main power supply furnishes $\pm$18, $\pm$15, and $\pm$5 volt dc power to operate the transport and the control, servo, and signal electronics. The control and servo electronics combine information from the various sensors, pushbuttons, and other sources to ensure gentle, reliable tape handling in all modes of operation.

4-8. The record and reproduce amplifiers and the optional monitor meter, voice logging, and tape servo control units are mounted in the amplifier cases. Up to 14 record and reproduce amplifiers of any combination (FM or direct) may be used in the system.

4-9. LED FOOTAGE COUNTER AND SHUTTLE CONTROL.

4-10. The LED footage counter and shuttle consist of a Counter board and a Counter Display and Shuttle Control board assembly. These boards are mounted on a common bracket with the loudspeaker used in the voice logger. With capstan motor tachometer pulses and direction information from the Capstan and Reel Servo board as input, the system counts tape usage in feet or meters depending on jumper selection. Recorder mode of operation (NORMAL or SHUTTLE) is selected by switches located in this system. Resetting the tape footage count to zero as well as setting the tape reversal point is accomplished by switch selection in this system.

4-11. DIRECT RECORD/REPRODUCE ELECTRONICS.

4-12. Each direct record/reproduce channel consists of one direct record amplifier and one direct reproduce amplifier. The bias signal of 4 MHz is furnished by the crystal controlled oscillator on the control logic board. A bias signal of 4 MHz is used because the bias signal should be at least 3.5 times greater than the highest data signal to be recorded. The direct record and reproduce amplifiers are constructed on printed circuit boards which plug into the amplifier cases. Operational controls, test points, and input/output connections are accessible on the front panels of the amplifiers.

4-13. The direct recording technique superimposes the analog input signal on the high-frequency bias signal and records the amplitude/time relationship of the analog input signal directly on magnetic tape. The direct record amplifier consists of two amplifier sections, a data amplifier and a bias amplifier; both signals are amplified to the desired level, linearly mixed, and then applied to the record head. The bias overcomes the hysteresis nonlinearity characteristic of the recording media. The data is amplified to a normal record level which produces one percent third harmonic distortion of the reproduced data signal. Since this is a function of magnetic tape saturation, if the record level is too high, excessive distortion will result; if too low, poor signal-to-noise ratio may result. Refer to Section V for the adjustment procedures for the data signal and bias levels.

4-14. The direct reproduce amplifier amplifies the signal recovered from the magnetic tape by the reproduce head and the preamplifier. The reproduce amplifier also equalizes the response of the direct record/reproduce system for each tape speed. The overall gain of the reproduce amplifier has a curve that is the inverse of the reproduce head response. Selection of the appropriate equalizer circuit is controlled automatically by the speed selector on the control panel. Refer to Section V for the adjustment procedures of the reproduce equalizers and amplifier gain. Since the adjustment procedures of the reproduce amplifiers are somewhat interactive, it is necessary to repeat the record and reproduce amplifier adjustments until the bias level, the normal record level, the equalizer, and the reproduce amplifier gain adjustments are all optimized.

4-15. FM RECORD/REPRODUCE ELECTRONICS.

4-16. Each FM record/reproduce channel consists of one FM record amplifier and one FM reproduce amplifier. The FM record amplifier may be utilized as either an IRIG Intermediate or Group I FM system. The center frequency for the appropriate usage is selected by a jumper on the FM record amplifier printed circuit board. The FM record and reproduce amplifiers are constructed on printed circuit boards which plug into the amplifier cases. Operational controls, test points, and input/output connections are accessible on the front panel of the units.

4-17. The FM recording technique modulates a carrier (center) frequency with the analog input signal and records the resulting frequency-modulated carrier on magnetic tape. The amplitude of the input analog signal determines the deviation percentage of the center frequency while the frequency of the input analog signal determines the rate at which the deviation changes. The full-scale modulation for a full-scale analog input level is plus or minus 40 percent deviation from the center frequency. The appropriate center frequency is controlled automatically by the speed selector switch on the control panel. Refer to Section V for the adjustment procedures for the percentage of deviation and center frequency adjustments.

4-18. The FM reproduce amplifier receives the frequency-modulated carrier from the preamplifier and amplifies, limits, and demodulates it to recover the amplitude and frequency of the original input signal. The principle of demodulation is used to integrate and filter a series of constant-area pulses which represent the modulated carrier. Each amplifier has provision for mounting two filters on the printed circuit card, therefore, the FM reproduce amplifiers are only electrically switchable for two speeds. However, any combination of filters may be installed on more than one FM reproduce amplifier to accommodate all the speeds. Each filter has a switch mounted on it whereby either the flat or the best-transient filter response may be selected. Refer to Section V for filter mounting instructions and amplifier adjustment procedures.

4-19. ACCESSORIES.

4-20. TAPE LOCK SERVO. The 12-471 Tape Lock Servo functions within the capstan speed control system. In the TACH position of the TACH/TAPE switch (mounted on the front panel), the capstan motor forms part of the closed loop servo system. In this system, the speed of the motor, as indicated by the tachometer, is compared to a crystal controlled reference frequency. In the TAPE position, the speed of the tape, as indicated by a prerecorded signal on any direct channel, is compared to the reference frequency for speed control. In this latter position, the speed of the tape is maintained to within $\pm$0.015 percent of the original speed at which the signal was recorded.

4-21. The unit is used in both recording and reproducing speed control signals at tape speeds of 15/16 ips to 60 ips. When in the reproduce mode, the unit receives a tape signal from the direct reproduce amplifier via the front panel BNC connector, filters and conditions it, then routes it to the speed control logic circuit. The

tape servo circuit also provides a TAPE MODE command to the control logic when the switch is in the TAPE position and the following Boolean expression is true:

$$\text{TAPE SIGNAL} \cdot \text{RUN} \cdot \overline{\text{RECORD}} \cdot \text{PHASE LOCK}$$

The control logic circuit then accepts the TAPE signal and uses it to control the speed of the capstan. In the record mode, the unit receives the appropriate tape speed frequency signal from the control logic, amplifies it, then routes it to a direct record amplifier via the front panel BNC connector.

4-22. The front panel also contains a TAPE LOCK indicator which illuminates when all conditions for the reproduce TAPE mode are met. The control logic circuitry will automatically switch to the TACH mode when the Boolean expression in the above paragraph is not true.

4-23. MONITOR METER. The monitor meter is a dc peak-to-peak reading meter which processes signals from the FM and direct record and reproduce amplifiers. Each of the amplifiers provides a normalized signal (adjusted after the normal record level, bias, center frequency, percentage of deviation, equalizers, and output level adjustments are correct) to the monitor meter. Any one of up to 7 record and 7 reproduce amplifiers may be selected for monitoring. The normalized signal from the amplifier will cause the meter to read 0 dB, which indicates that the input and output levels are proper.

4-24. FM SYSTEM CALIBRATOR. The 12-455 FM Calibrator is constructed on a printed circuit board similar to the record/reproduce amplifiers. The FM calibrator plugs into the position normally occupied by the monitor meter.

4-25. In frequency modulation recording and reproducing, the amplitude/time relationship of the data input signal is first converted to a frequency time relationship and then recorded on magnetic tape as frequency deviations about the FM center frequency. The rate at which the recorded frequency varies about the center frequency is determined by the frequency of the data signal. To reproduce and recover the data input signal to its original amplitude and frequency is the function of the FM reproduce amplifier. Using only the FM calibrator, the record and reproduce amplifiers may be aligned with a resolution and accuracy approaching those of using a digital counter and digital voltmeter.

4-26. VOICE LOGGING UNIT. The 12-478C-2 Voice Logging Unit is a plug-in circuit card located in the amplifier case assembly. The voice logging unit may be used to record and reproduce voice commentary on a special track at the edge of the magnetic tape. The heads included with the tape system provide one voice track adjacent to the data tracks.

4-27. REMOTE CONTROL ASSEMBLY. The 12-487B-1 Remote Control Assembly enables remote operation of the 4020A system through mode and speed selection switches and indicators. The 12-487B-1 Remote Control Assembly is a portable assembly. The remote control is operational when the speed selector switch on the tape transport

control panel is placed in the REMOTE (R) position. In this condition, local control of speed and mode selection is disabled thereby permitting speed and mode selection by the remote control assembly.

4-28. BIN LOOP ADAPTER. The 12-483-2 (1/2 inch) and 12-483-5 (1 inch) Bin Loop Adapters allow the 4020A system to operate continuously with an endless loop of tape at any of the nine available tape speeds. Mounting holes to accommodate field installation of the bin loop adapter have been predrilled and threaded at the factory. Tape lengths of 6 to 50 feet are acceptable and are good for up to 2000 passes at 60 ips.

SECTION V

CALIBRATION AND MAINTENANCE

5-1. GENERAL.

5-2. Maintenance of this system should be performed only by qualified technicians and personnel familiar with this type of equipment. The procedures described in this section pertain to maintenance on a system basis only. For detailed maintenance procedures for the major components of the system, refer to the applicable operation and maintenance manual.

5-3. Only parts of the highest quality have been used in the manufacture of this system. Replacement parts should be either Bell & Howell parts or parts of comparable quality if the inherent reliability built into the system is to be maintained. Refer to Section VI of this manual for replacement part lists for the head assemblies, tape width kits, and rackmounting kits. Refer to Section VI of the component manuals for the replacement part lists and part locations of all components.

5-4. PREVENTIVE MAINTENANCE.

5-5. Preventive maintenance consists of periodic visual inspection and cleaning.

5-6. VISUAL INSPECTION. Accumulation of dust, dirt, grit, or grease is harmful and should be guarded against by periodic visual inspection and cleaning. Every three months, inspect the system components for signs of deterioration, loose connections, insecurity of mounting, and general cleanliness. Clean, replace, or repair, as applicable, any defects found.

5-7. To begin the visual inspection, remove power from the system and proceed as follows:

a. Remove the electronic amplifier circuit boards.

NOTE

As printed wiring boards are extracted, tag them or put them down in the same order as they were installed in the equipment, so that they can be replaced in their original positions. Interchanging printed wiring boards requires readjustment of the system.

b. Remove the attachment screws and lower the amplifier case assembly to the rear (portable configuration only). Remove the capstan belt cover and the control panel cover from the transport. Remove the control logic and servo circuit cards.

CAUTION

When handling any of the long printed circuit cards, use extreme care not to bend the card as this could cause permanent damage to the circuit by cracking or separating the etched circuit. Be careful when handling any printed wiring.

5-8. Inspect parts for signs of damage or deterioration, insecurity of mounting, or loose connections, and repair or replace as required. Check the capstan belt for cleanliness and proper tension.

5-9. Inspect all electrical contacts and clean, as required, using a standard contact cleaning fluid.

5-10. Inspect the air filter by removing the right-hand side panel, and clean or replace, as required. Environmental conditions will determine how often the filter should be checked and cleaned; however, this period should be no longer than three months under clean, air conditioned, laboratory conditions.

5-11. CLEANING. Remove dust, dirt, grease, and other foreign material from the system. Clean delicate parts with a soft brush and larger harder surfaces with a cloth. If necessary, use a suitable cleaning solvent. Blow away the loose particles using low-pressure air.

5-12. CLEANING TAPE HANDLING COMPONENTS. A particularly important part of preventive maintenance is the cleaning of all tape handling components, especially the magnetic heads. All surfaces contacted by the magnetic tape (heads, tape guides, rollers, etc.) should be cleaned with a soft lint-free cloth moistened, not saturated, with DuPont Freon TF. Be careful not to mar the surface of the components, and be sure to remove all excess fluid after cleaning.

CAUTION

The CAPSTANS are urethane coated, and therefore very susceptible to becoming tacky by the action of most chemicals. The capstans should be cleaned with a solution of soft soap and warm water.

CAUTION

Only DuPont Freon TF should be used to clean the tape handling components (EXCEPT for the CAPSTAN). It is nontoxic and nonflammable. DO NOT USE carbon tetrachloride, alcohol, trichloroethylene, or any cleaning agent which might be detrimental to the tape handling surfaces.

NOTE

Cleaning of the tape handling components is required on a daily basis or sooner as determined by the frequency and the environment in which the system is operated.

5-13. DIRECT RECORD/REPRODUCE ALIGNMENT PROCEDURES.

5-14. In any direct recording process, the characteristics of wide frequency response, low distortion, and high signal-to-noise ratio are dependent one on the other, so that the best of any one characteristic can be achieved only at the expense of the others. Peak system adjustment represents a balance between these factors rather than the optimum of any one. The procedures given below are for peak operational adjustment of the direct system circuits. For maintenance adjustment, refer to the individual manuals for the components which make up the system.

5-15. Adjustments of the direct record system are necessary when the amplifiers are changed, a head stack is changed, a different type of tape is used, or following replacement of amplifier components. Readjustment of the record level is also necessary if a new, normal record level is established. Normal record level is the level of record head current required to produce one percent third harmonic distortion of the reproduced signal at the record set frequency when the distortion is a function of magnetic tape saturation and is not a function of electronic circuitry. The adjustment procedures presuppose that the tape transport is correctly set up and adjusted; that adjustment requiring tape movement will be made with the tape transport in phase lock; and that the test equipment listed in table 5-1 is stabilized. Perform the procedures one channel at a time.

EQUIPMENT	USE
Tape System Calibrator: Bell & Howell Model TSC-2000. If not available, the following may be substituted.	All calibration functions except visual display of signals.
AC Voltmeter: Hewlett-Packard 400 FL, or equivalent	Bias level and input and output setting.
Oscilloscope: Tektronix 7403N with 7B53A Time Base and 7A18 Amplifier, or equivalent	Observations of input and output signals.

Table 5-1. List of Test Equipment for Direct System Alignment (Sheet 1 of 2)

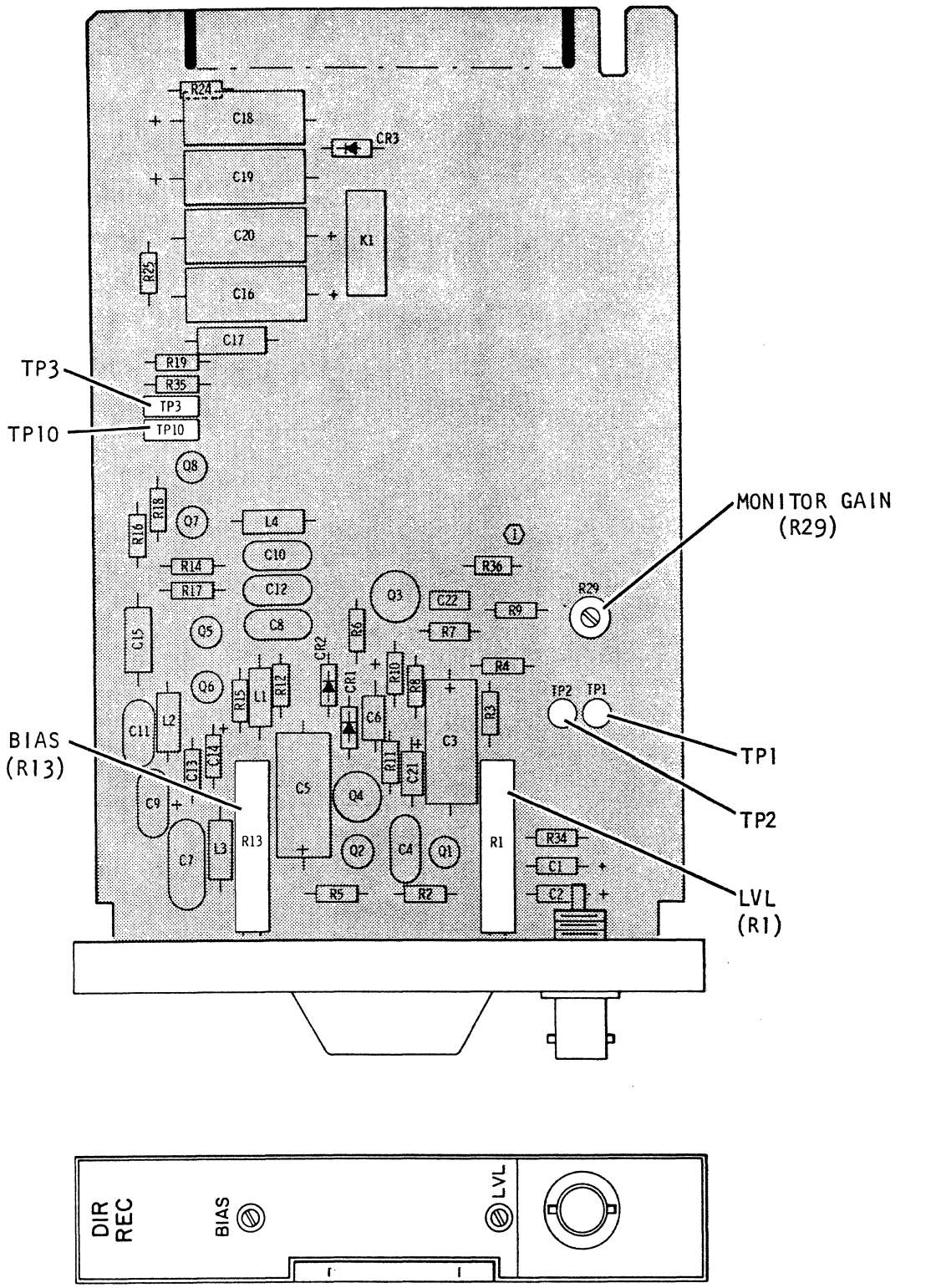
EQUIPMENT	USE
Sine Wave Generator: Hewlett-Packard 651B, or equivalent	Bias level, record level, and equalization adjustment.
Wave Analyzer: Hewlett-Packard 310A, or equivalent	Record level adjustment.
Extender Card: Bell & Howell part number 379634	To gain access to circuit card components.
Recommended magnetic tape	See paragraph 3-8(a).

Table 5-1. List of Test Equipment for Direct System Alignment (Sheet 2 of 2)

5-16. DIRECT RECORD AMPLIFIER CONTROLS AND TEST POINTS. The function of each control and test point is summarized in table 5-2. The locations of the controls and test points are shown in figure 5-1.

CONTROLS AND TEST POINTS	FUNCTION
LVL (Record Level Control, R1)	Signal input attenuator. Controls the input to produce the normal record level.
BIAS (Bias Level Control, R13)	Potentiometer which controls the output of the bias amplifier. Adjustable to produce the proper bias level.
Monitor Gain Control, R29	Adjusts the optional monitor meter to read 0 dB for each channel after normal record level and bias level adjustments are made.
TP1 (brown)	Monitors signal output.
TP2 (red)	Monitors data amplifier section output.
TP3 (orange)	Head current monitor (low side of head).
TP10 (black)	Ground.

Table 5-2. Controls and Test Points, 12-442 Direct Record Amplifier



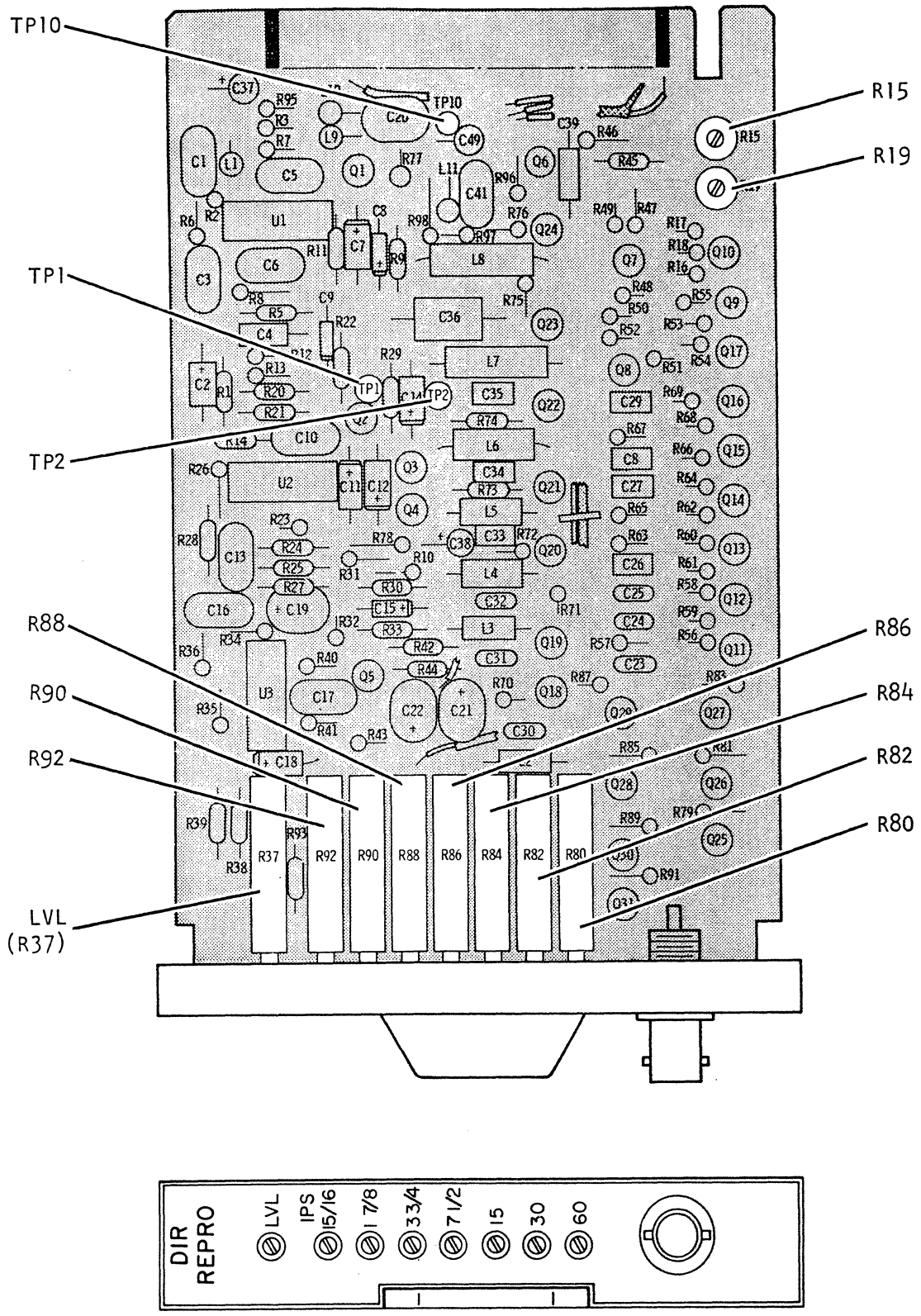
D-379467-XXX1(REF)

Figure 5-1. Controls and Test Point Locations, Direct Record Amplifier

5-17. INTERMEDIATE BAND DIRECT REPRODUCE AMPLIFIER CONTROLS AND TEST POINTS. The function of each control and test point is listed in table 5-3. The location of each control and test point is shown in figure 5-2.

CONTROLS AND TEST POINTS	FUNCTION
LVL (R37)	Adjusts output signal level, up to 4 V p-p into 600 ohms.
R80 (60 ips)	60 ips high frequency gain adjustment.
R82 (30 ips)	30 ips high frequency gain adjustment.
R84 (15 ips)	15 ips high frequency gain adjustment.
R86 (7-1/2 ips)	7-1/2 ips high frequency gain adjustment.
R88 (3-3/4 ips)	3-3/4 ips high frequency gain adjustment.
R90 (1-7/8 ips)	1-7/8 ips high frequency gain adjustment.
R92 (15/16 ips)	15/16 ips high frequency gain adjustment.
R15	Adjusts midband gain from 7-1/2 ips to 60 ips.
R19	Adjusts midband gain from 15/16 ips to 3-3/4 ips.
TP1 (brown)	Monitor point for summing point 1.
TP2 (red)	Monitor point for summing point 2.
TP10 (black)	Ground.

Table 5-3. Controls and Test Points, 12-447C Direct Reproduce Amplifier



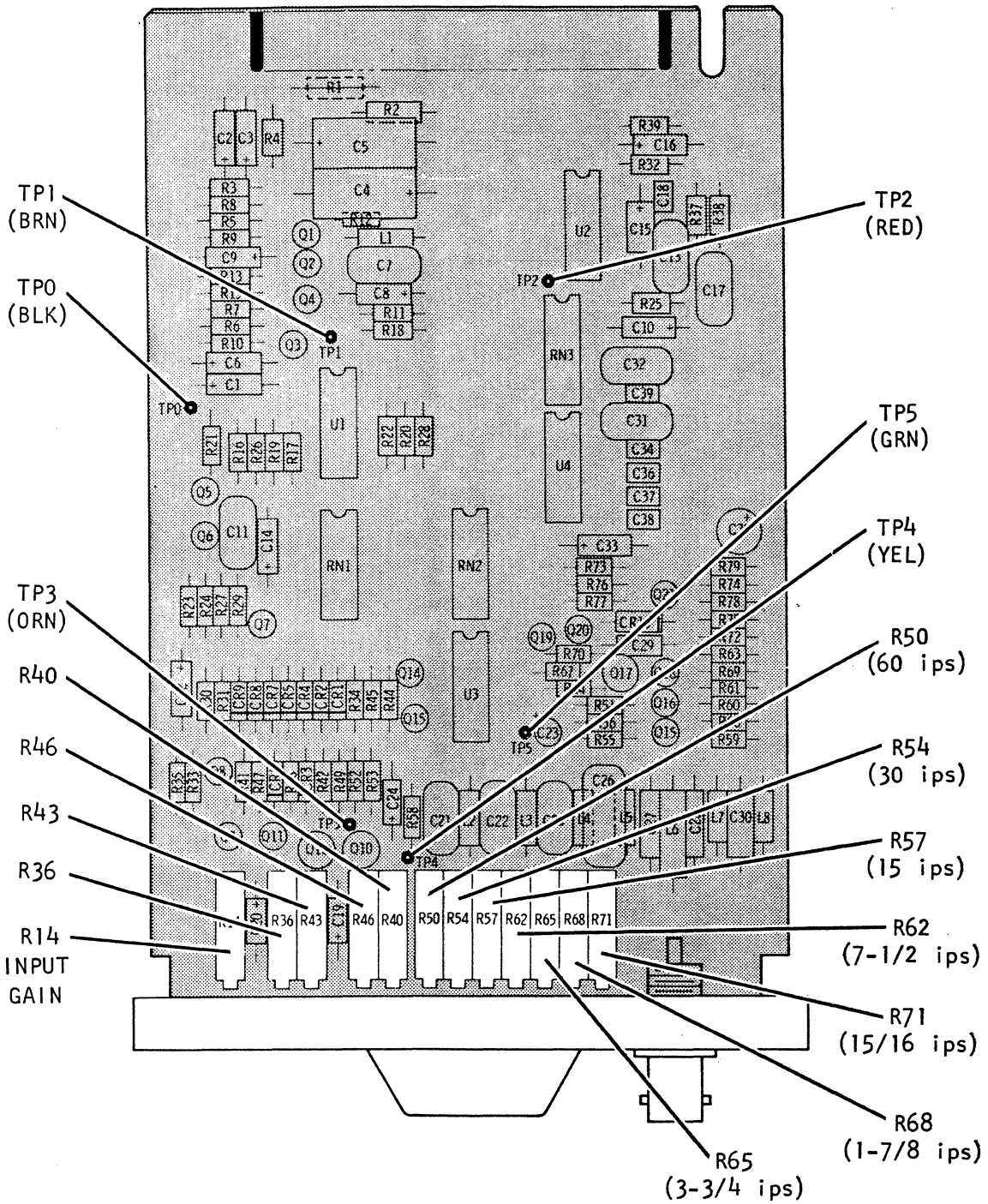
D-379512-0001 (REF)

Figure 5-2. Controls and Test Point Locations, 12-447C Direct Reproduce Amplifier

5-18. WIDE BAND DIRECT REPRODUCE AMPLIFIER CONTROLS AND TEST POINTS. The function of each control and test point is listed in table 5-4. The location of each control and test point is shown in figure 5-3.

CONTROLS AND TEST POINTS	FUNCTION
Input Gain, R14	Adjusts overall amplifier gain.
R36	2/3 band edge, high range adjustment.
R40	0.1 band edge, low range adjustment.
R43	2/3 band edge, low range adjustment.
R46	0.1 band edge, high range adjustment.
R50 (60 ips)	60 ips high frequency gain adjustment.
R54 (30 ips)	30 ips high frequency gain adjustment.
R57 (15 ips)	15 ips high frequency gain adjustment.
R62 (7-1/2 ips)	7-1/2 ips high frequency gain adjustment.
R65 (3-3/4 ips)	3-3/4 ips high frequency gain adjustment.
R68 (1-7/8 ips)	1-7/8 ips high frequency gain adjustment.
R71 (15/16 ips)	15/16 ips high frequency gain adjustment.
TP0 (black)	Ground.
TP1 (brown)	Monitors the output of the input amplifier stage.
TP2 (red)	Low frequency equalization amplifier output.
TP3 (orange)	0.1 band edge monitor.
TP4 (yellow)	2/3 band edge and high frequency equalization monitor.
TP5 (green)	Monitors the output of the equalization circuits.

Table 5-4. Controls and Test Points, 12-447C-1 Direct Reproduce Amplifier



D-534380-X2 (REF)

Figure 5-3. Controls and Test Point Locations, 12-447C-1 Direct Reproduce Amplifier

5-19. DIRECT SYSTEM ALIGNMENT PROCEDURES. Figure 5-4 illustrates the setup for the operational adjustments. The upper band edge frequency for each tape speed is given in table 5-5. First the record amplifier is adjusted and then the reproduce amplifier.

TAPE SPEED (ips)	INTERMEDIATE BANDWIDTH (kHz)	WIDE BAND (kHz)
60	300	1000
30	150	500
15	75	250
7-1/2	37.5	125
3-3/4	18.75	62.50
1-7/8	9.300	31.25
15/16	4.650	16.00

Table 5-5. Upper Band Edge Frequencies, Direct

5-20. DIRECT RECORD AMPLIFIER ALIGNMENT PROCEDURES. Perform the following steps:

CAUTION

Turn system power OFF before removing or replacing a circuit card in an amplifier case.

a. Mount the direct record amplifier to be adjusted on an extender card.

b. Apply power to the record/reproduce system. Do not run tape. Allow 10 minutes for temperature stabilization.

c. Connect the test equipment to the record/reproduce system as shown in figure 5-4.

d. Set the sine wave generator to 1 kHz (wide band 50 kHz) with an output amplitude equal to the expected data signal level (0.5 V to 20 V peak-to-peak). (Maximum permissible input power level is 0.5 watt.)

e. Adjust the LVL potentiometer, R1, on the front panel of the direct record amplifier for a 140 mV rms reading on the ac voltmeter connected to TP2. This should set the record level to a value approximately 6 dB below the final level to permit the bias level to be properly adjusted. Turn power off and remove the record amplifier from the extender card, replacing it in the amplifier case.

f. Set the sine wave generator to 150 kHz (wide band 500 kHz); do not change the output level.

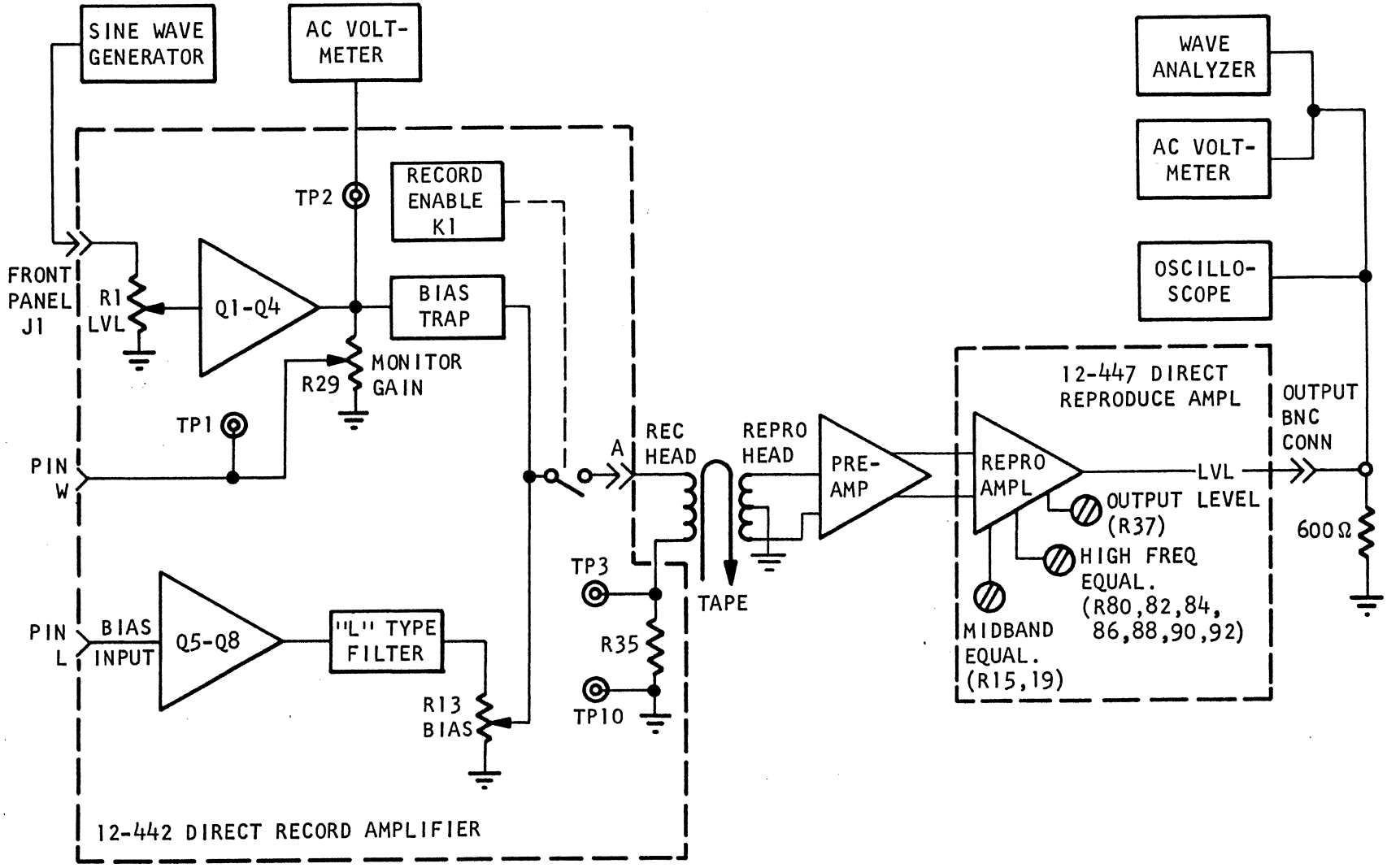


Figure 5-4. Test Equipment Setup for Direct Electronics Procedure Alignment

g. Install a reel of bulk-erased intermediate band (wide band) instrumentation tape. See paragraph 3-8(a).

h. At 30 ips, simultaneously record and reproduce the 150 kHz (500 kHz) signal and adjust the BIAS potentiometer, R13, on the direct record amplifier front panel clockwise until the ac voltmeter on the output of the reproduce amplifier is peaked. Continue the clockwise bias potentiometer adjustment until the output drops 3 dB (wide band 2 dB). This indicates an overbias level.

i. Stop the transport and set the sine wave generator to 1 kHz (50 kHz). Connect the wave analyzer to the reproduce amplifier output.

j. At 30 ips, simultaneously record and reproduce the 1 kHz (50 kHz) signal.

k. Tune the wave analyzer to the third harmonic and measure the level of the third harmonic, relative to the fundamental.

m. If the third harmonic distortion measured in step k is over one percent, reduce the direct record amplifier LVL potentiometer (R1) setting and readjust the bias, as in step h.

n. Record and reproduce the 1 kHz (50 kHz) signal and adjust the direct record amplifier LVL potentiometer (R1) for exactly one percent third harmonic distortion. (Remember, the fundamental level is also affected by the direct record amplifier LVL potentiometer.)

p. When normal record level has been adjusted, adjust test signal (1/10 BE) input to calibration level, and adjust monitor gain potentiometer R29 for 100 mV rms at test point TP1.

NOTE

Should a check of the reproduce amplifier reveal that an equalization adjustment is required, it will be necessary to recheck the record amplifier adjustments.

q. Repeat the above procedures for all remaining direct record amplifiers.

5-21. INTERMEDIATE BAND DIRECT REPRODUCE AMPLIFIER ALIGNMENT PROCEDURES. Perform the following steps:

CAUTION

Turn system power OFF before removing or replacing a circuit card in an amplifier case.

a. Place the reproduce amplifier circuit card for the channel being adjusted in an extender card.

b. Set the sine wave generator to 1 kHz with the output amplitude equal to the expected data signal level.

c. Connect an ac voltmeter to the output of the reproduce amplifier.

d. Place the transport in the RECORD mode, and select a tape speed of 30 ips.

e. Adjust R37 (LVL control) in the direct reproduce amplifier for an output reading of 1 Vrms.

f. Set the sine wave generator for 1/4 upper band edge (37.5 kHz). Adjust R15 (mid-band control) in the direct reproduce amplifier for an output reading of 1.06 V rms.

g. Set the sine wave generator at upper band edge (150 kHz). Adjust the 30 ips potentiometer, R82, in the direct reproduce amplifier for an output reading of 1 V rms.

h. Repeat steps e, f, and g for fine adjustment since the controls will interact.

i. Select a tape speed of 60 ips. Set the sine wave generator for upper band edge (300 kHz). Adjust the 60 ips potentiometer (R80, band edge control) in the direct reproduce amplifier for an output reading of 1 V rms.

j. Select a tape speed of 15 ips. Set the sine wave generator for upper band edge (75 kHz). Adjust the 15 ips potentiometer (R84, band edge control) in the direct reproduce amplifier for 1 V rms.

k. Select a tape speed of 7-1/2 ips. Set the sine wave generator for upper band edge (37.5 kHz). Adjust the 7-1/2 ips potentiometer (R86, band edge control) in the direct reproduce amplifier for 1 V rms.

m. Select a tape speed of 1-7/8 ips. Set the sine wave generator at 500 Hz and adjust LVL control (R37) in the direct reproduce amplifier for 1 V rms.

n. Set the sine wave generator at 1/4 band edge (2.325 kHz) and adjust R19 (mid-band control) in the direct reproduce amplifier for an output of 1.06 V rms.

p. Set the sine wave generator at upper band edge (9.3 kHz) and adjust 1-7/8 ips potentiometer (R90, band edge control) in the direct reproduce amplifier for an output of 1 V rms.

q. Repeat steps m, n, and p for fine adjustment since the controls will interact.

r. Select a tape speed of 3-3/4 ips. Set the sine wave generator to upper band edge (18.75 kHz) and adjust the 3-3/4 ips potentiometer (R88, band edge control) in the direct reproduce amplifier for an output of 1 V rms.

s. Select a tape speed of 15/16 ips. Set the sine wave generator to upper band edge (4.65 kHz) and adjust 15/16 ips potentiometer (R92, band edge control) in the direct reproduce amplifier for an output of 1 V rms.

t. Press the STOP pushbutton. Remove all test equipment and place the direct reproduce amplifier circuit card in its normal position in the amplifier case.

u. Repeat the above procedures for each of the remaining intermediate band direct reproduce amplifiers.

5-22. WIDE BAND DIRECT REPRODUCE AMPLIFIER ADJUSTMENT PROCEDURES. Perform the following steps:

CAUTION

Turn system power OFF before removing or replacing a circuit card in an amplifier case.

a. Set the sine wave generator to 1 kHz with the output amplitude equal to the expected data signal level (0.5 to 20 V peak-to-peak).

b. Connect an ac voltmeter to the output of the reproduce amplifier.

c. Place the transport in the RECORD mode at 30 ips.

d. Adjust R14 (LVL) in the direct reproduce amplifier for an output of 1 V rms.

e. Set the sine wave generator to 300 kHz and adjust R36 (2/3 band edge "HI") for 1 V rms.

f. Set the sine wave generator to 50 kHz and adjust R46 (1/10 band edge "HI") for 1 V rms.

g. Set the sine wave generator to 500 kHz and adjust R54 (30) for 1 V rms.

h. Select a tape speed of 60 ips.

i. Set the sine wave generator to 1 MHz and adjust R50 (60) for 1 V rms.

j. Select a tape speed of 15 ips.

k. Set the sine wave generator to 250 kHz and adjust R57 (15) for 1 V rms.

m. Select a tape speed of 7-1/2 ips.

n. Set the sine wave generator to 83 kHz and adjust R43 (2/3 band edge "LO") for 1 V rms.

p. Set the sine wave generator to 12.5 kHz and adjust R40 (1/10 band edge "LO") for 1 V rms.

q. Set the sine wave generator to 125 kHz and adjust R62 (7-1/2) for 1 V rms.

r. Select a tape speed of 3-3/4 ips.

s. Set the sine wave generator to 62 kHz and adjust R65 (3-3/4) for 1 V rms.

t. Select a tape speed of 1-7/8 ips.

u. Set the sine wave generator to 31 kHz and adjust R68 (1-7/8) for 1 V rms.

v. Select a tape speed of 15/16 ips.

w. Set the sine wave generator to 16 kHz and adjust R71 (15/16) for 1 V rms.

x. Repeat the above procedures for each of the remaining wide band reproduce amplifiers.

5-23. FREQUENCY MODULATION RECORD/REPRODUCE ALIGNMENT PROCEDURES.

5-24. Adjustment of the FM electronics is necessary when establishing a recording level and following parts replacement. The following FM record/reproduce amplifier adjustment procedures presuppose that all other components of the tape system using the FM amplifiers are correctly set up and adjusted. These procedures also assume that the adjustments requiring tape movements will be made with the transport in phase lock and that the test equipment listed in table 5-6 is available.

EQUIPMENT	USE
Tape System Calibrator: Bell & Howell Model TSC-2000. If not available, the following may be substituted.	All calibration functions except visual display of signals.
AC Voltmeter: Hewlett-Packard 400FL, or equivalent	Record level adjustment.
Counter: Hewlett-Packard 5326 with X10 probe, or equivalent	Center frequency adjustments, frequency deviation adjustment; dc offset adjustment.
DC Voltmeter, Digital: Hewlett-Packard 3439A with 3442A plug-in unit, or equivalent	Frequency deviation adjustment; dc offset adjustment; record level adjustment.
DC Power Supply: Hewlett-Packard 6213A with output floating, or equivalent	Frequency deviation adjustment; dc offset adjustment.
Sine Wave Generator: Hewlett-Packard 651B, or equivalent	System gain adjustment.
Wave Analyzer: Hewlett-Packard 310A, or equivalent	Balance and head current adjustments.
Extender Card: Bell & Howell part number 379634	Access to circuit card components.
Recommended magnetic tape: See paragraph 3-8(a)	

Table 5-6. List of Test Equipment Required for FM Record/Reproduce Alignment Procedures

5-25. FM RECORD AMPLIFIER 12-454A, CONTROLS AND TEST POINTS. The function of each control and test point for the FM Record Amplifier 12-454A is summarized in table 5-7. The location of each control is shown in figure 5-5.

CONTROLS AND TEST POINTS	FUNCTION
Frequency Deviation	
ΔFc (Coarse Adjustment, R2)	Attenuates the incoming data signal.
ΔFf (Fine Adjustment, R3)	Fine adjustment of incoming data signal attenuation.
Carrier Center Frequency	
CFc (Coarse Adjustment, R5)	Sets center frequency to its nominal value. It is adjustable for ±40% span of center frequency. May be used as a dc offset to counter a steady-state shift of the carrier frequency caused by a data signal which produces a dc component.
CFf (Fine Adjustment, R6)	Fine adjustment of carrier center frequency. Adjustable for a ±10% span of center frequency.
Head Current Adjustment, R37	Sets record level by controlling the amount of record head current.
Monitor Record Level, R25	Adjustment for 0 dB on the optional monitor meter.
Monitor DC Null, R35	Null adjustment for optional monitor meter.
MON (TP2, red)	Monitor point for the output of the dc amplifier.
TP4 (orange)	Monitor point for carrier frequency at the output of the frequency divider.
TP3 (yellow)	Monitor point for FM record signal at the output of the record head driver amplifier.
GND (TP1, black)	Monitor point for ±15 Vdc power supply common.

Table 5-7. Controls and Test Points, 12-454A FM Record Amplifier

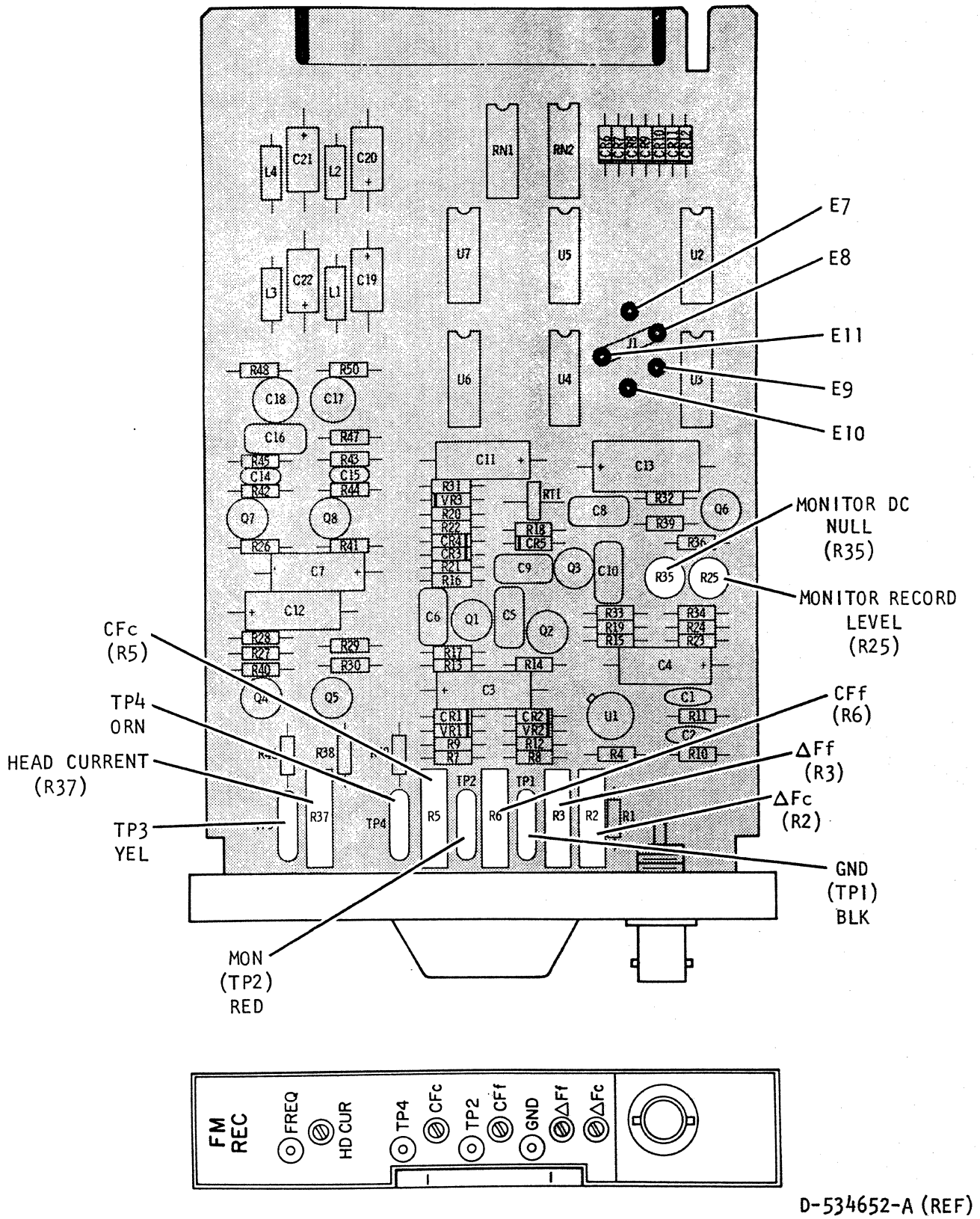


Figure 5-5. Controls and Test Point Locations, 12-454A FM Record Amplifier

5-26. FM RECORD AMPLIFIER 12-454B, CONTROLS AND TEST POINTS. The function of each control and test point for the FM Record Amplifier 12-454B is summarized in table 5-8. The location of each control is shown in figure 5-6.

CONTROLS AND TEST POINTS	FUNCTION
Frequency Deviation ΔF (Coarse Adjustment, R64)	Attenuates the incoming data signal.
Carrier Center Frequency CFc (Coarse Adjustment, R71)	Sets center frequency to its nominal value. It is adjustable for ±40% span of center frequency. May be used as a dc offset to counter a steady-state shift of the carrier frequency caused by a data signal which produces a dc component.
CFf (Fine Adjustment, R83)	Fine adjustment of carrier center frequency. Adjustable for a ±10% span of center frequency.
Head Current Adjustment, R94 R93 R92	Sets record level by controlling the amount of record head current. Intermediate Band Wide Band. Extended Wide Band.
Input Stage Offset, R6, R13	Adjustment for 0 volts with input shorted.
5 V STAB, R80	Adjusts 5 volt regulator.
TP6	Monitor point for the output of the input amplifier.
TP4	Ground.
TP3	Monitor point for FM record signal at the output of the record head driver amplifier.
TP5	Monitor point for +5 Vdc power supply.

Table 5-8. Controls and Test Points, 12-454B FM Record Amplifier

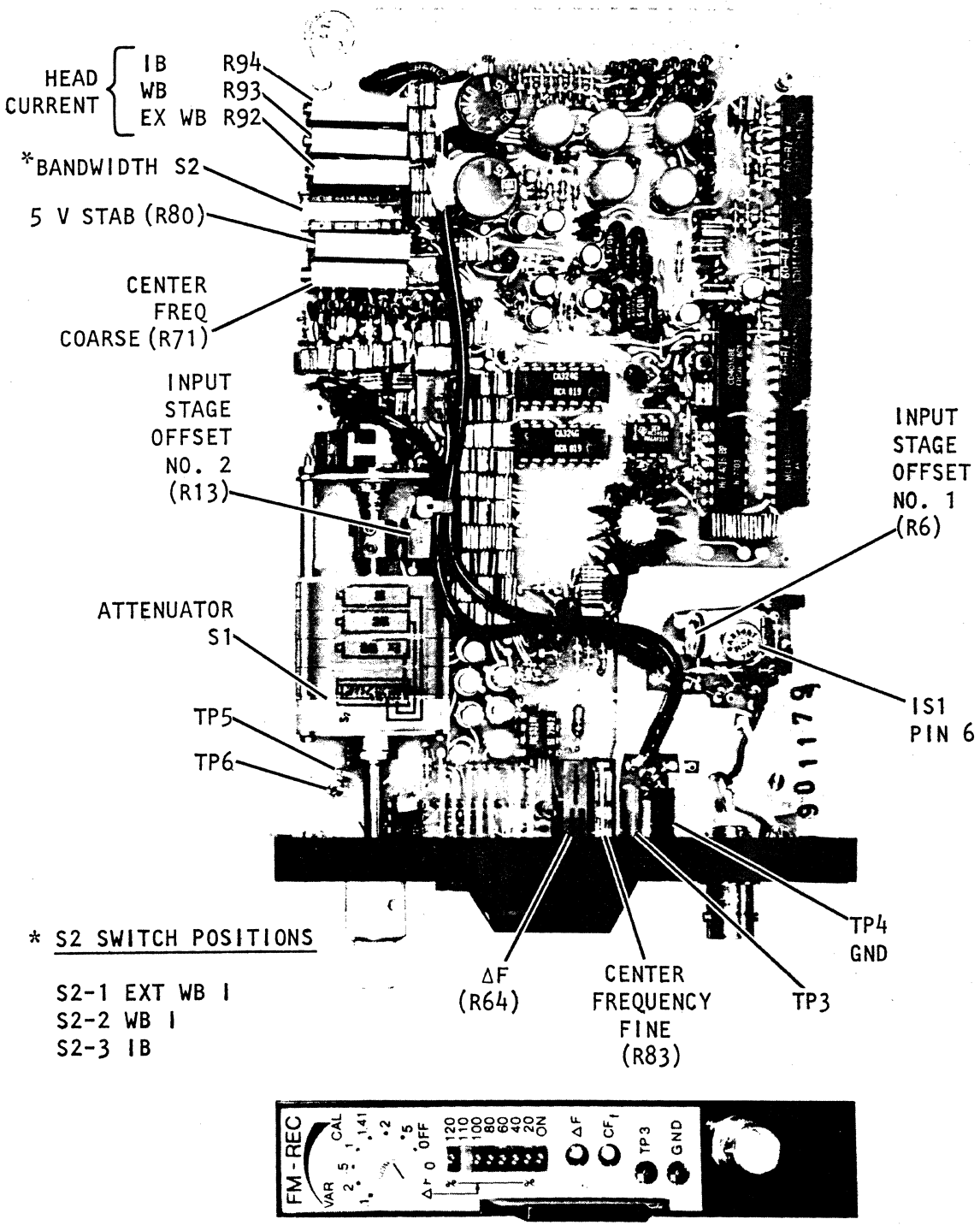


Figure 5-6. Controls and Test Point Locations, 12-454B FM Record Amplifier

5-27. FM REPRODUCE AMPLIFIER 12-457G, CONTROLS AND TEST POINTS. The function of each control and test point for the FM Reproduce Amplifier 12-457G is listed in table 5-9. Figure 5-7 shows the location of the controls and test points.

CONTROLS AND TEST POINTS	FUNCTION
TP1 (brown)	Monitor point for carrier prior to limiting.
TP10 (black)	Ground.
DC OFS (Offset Control, R45)	Adjust to produce zero output of the FM reproduce amplifier for unmodulated carrier frequency input.
LVL (Level Control, R69)	Adjusts the overall gain of the reproduce amplifier.
Balance Control, R42	Balances currents in constant-area pulse generator.
Center Frequency Vernier Controls, R56 and R58	Adjust to compensate for tolerances in the constant-area pulse components and to compensate for incorrect center frequency during record.
Filter Response Switches (On each low pass filter)	Select flat frequency response or best-transient response.
TP2 (red)	Monitor point for constant-area pulse train.

Table 5-9. Controls and Test Points, 12-457G FM Reproduce Amplifier

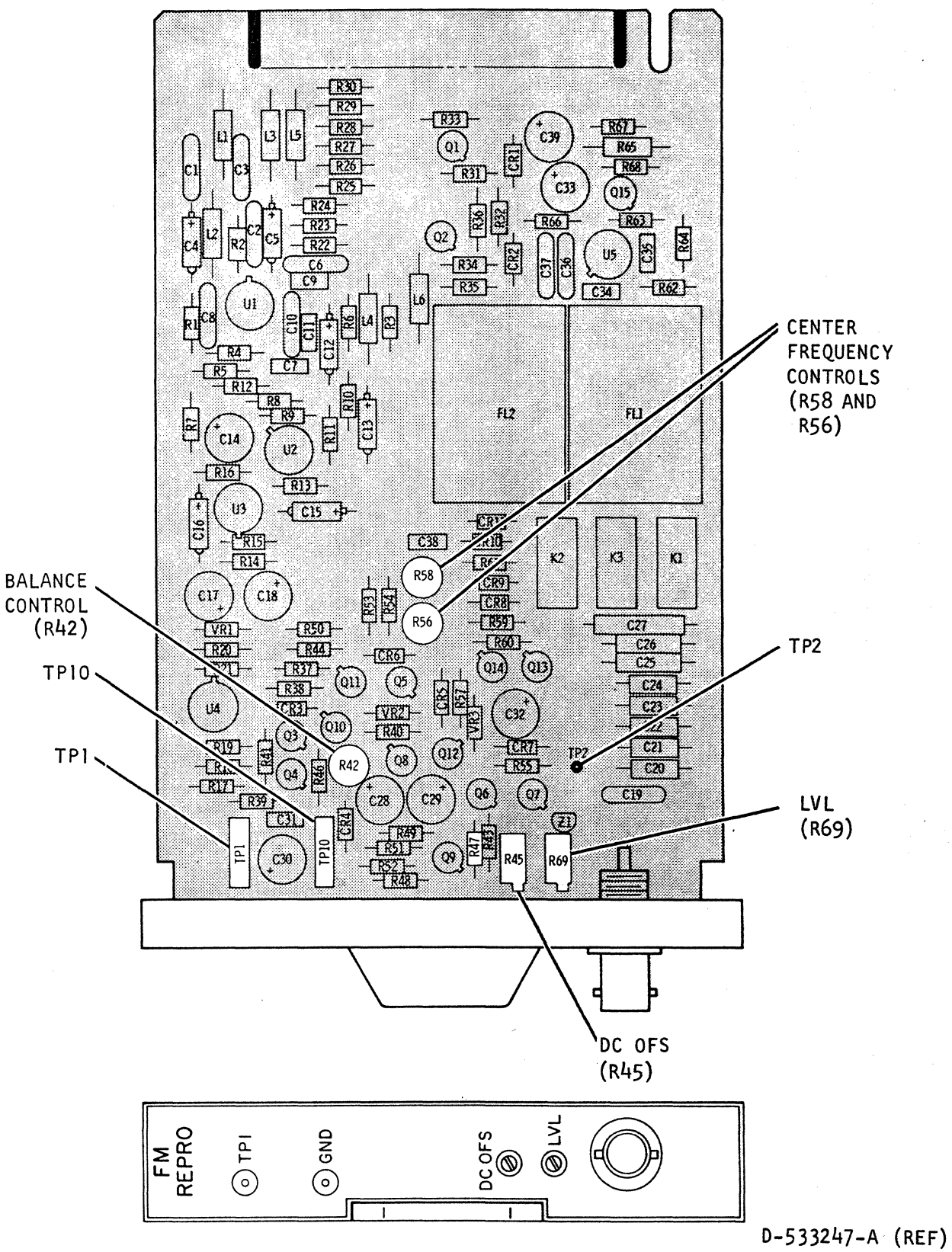


Figure 5-7. Controls and Test Point Locations, 12-457G
FM Reproduce Amplifier

5-28. FM REPRODUCE AMPLIFIER 12-457C, CONTROLS AND TEST POINTS. The function of each control and test point for the FM Reproduce Amplifier 12-457C is listed in table 5-10. Figure 5-8 shows the location of the controls and test points.

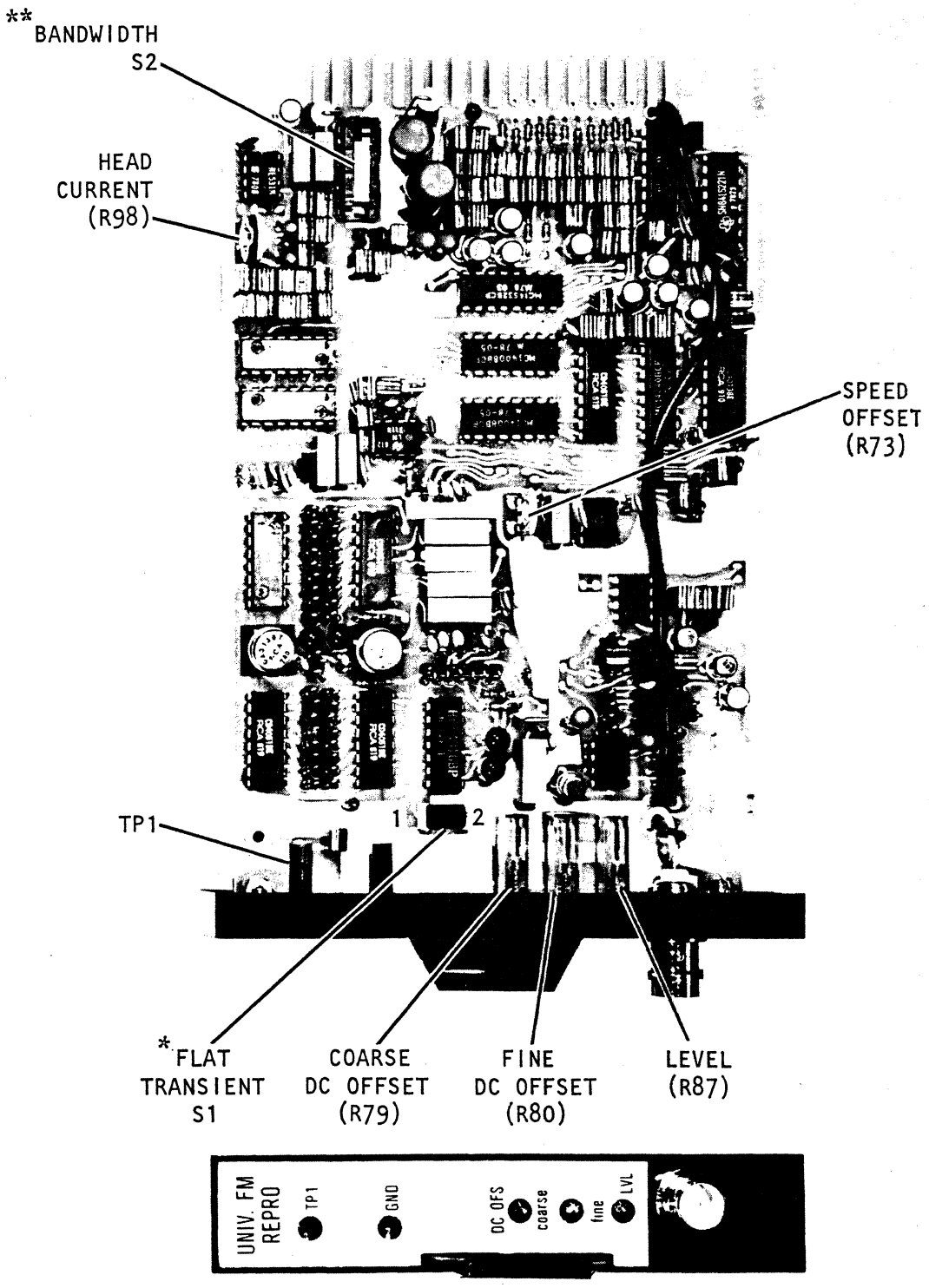
CONTROLS AND TEST POINTS	FUNCTION
TP1	Monitor point for carrier prior to limiting.
DC OFS Coarse (Offset Control, R79)	Adjust to produce zero output of the FM reproduce amplifier for unmodulated carrier frequency input.
DC OFS Fine (Offset Control, R80)	
LVL (Level Control, R87)	Adjusts the overall gain of the reproduce amplifier.
Head Current, R98	Adjusts input level of the reproduce amplifier.
Speed Offset, R73	Adjusts to compensate level for all tape speeds.
Filter Response Switch (S1)	Select flat frequency response or best-transient response.
Bandwidth Switch (S2)	Compensates level for all bandwidths.

Table 5-10. Controls and Test Points, 12-457C FM Reproduce Amplifier

5-29. BANDWIDTH SELECTION. Either IRIG Intermediate Band, IRIG Wide Band Group I, IRIG Extended Wide Band Group I, or IRIG Low Band may be selected by connecting the appropriate jumpers on the FM record and reproduce amplifiers or by switch positions. Refer to tables 5-11 through 5-14 for the FM record/reproduce amplifier jumper configurations.

IRIG EXTENDED WIDE BAND GROUP I	E11 to E7
IRIG WIDE BAND GROUP I	E11 to E8
IRIG INTERMEDIATE BAND	E11 to E9
IRIG LOW BAND	E11 to E10

Table 5-11. 12-454A FM Record Amplifier Jumper Configuration



* S1 SWITCH POSITIONS

S1-1 FLAT (BUTTERWORTH)
S1-2 TRANSIENT (BESSEL)

** S2 SWITCH POSITIONS

S2-1 INTERMEDIATE BAND
S2-2 WIDE BAND I
S2-3 EXT. WIDE BAND I

Figure 5-8. Controls and Test Point Locations, 12-457C FM Reproduce Amplifier

EXTENDED WIDE BAND GROUP I

FILTER NO. 1					FILTER NO. 2				
SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN	SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN
80	60	E24-E33	E1-E3	E21-E14	40	30	E23-E34	E2-E4	E22-E15
40	30	E24-E34	E1-E4	E21-E15	20	15	E23-E35	E2-E5	E22-E16
20	15	E24-E35	E1-E5	E21-E16	10	7-1/2	E23-E36	E2-E6	E22-E17
10	7-1/2	E24-E36	E1-E6	E21-E17	5	3-3/4	E23-E37	E2-E7	E22-E18
5	3-3/4	E24-E37	E1-E7	E21-E18	2.5	1-7/8	E23-E38	E2-E8	E22-E19
2.5	1-7/8	E24-E38	E1-E8	E21-E19	1.25	15/16	E23-E39	E2-E9	E22-E20
1.25	15/16	E24-E39	E1-E9	E21-E20	--	--	---	---	---

Table 5-12. 12-457G FM Reproduce Amplifier Jumper Configuration for Extended Wide Band Group I

WIDE BAND GROUP I

FILTER NO. 1					FILTER NO. 2				
SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN	SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN
40	60	E24-E33	E1-E4	E21-E13	20	30	E23-E34	E2-E5	E22-E14
20	30	E24-E34	E1-E5	E21-E14	10	15	E23-E35	E2-E6	E22-E15
10	15	E24-E35	E1-E6	E21-E15	5	7-1/2	E23-E36	E2-E7	E22-E16
5	7-1/2	E24-E36	E1-E7	E21-E16	2.5	3-3/4	E23-E37	E2-E8	E22-E17
2.5	3-3/4	E24-E37	E1-E8	E21-E17	1.25	1-7/8	E23-E38	E2-E9	E22-E18
1.25	1-7/8	E24-E38	E1-E9	E21-E18	0.625	15/16	E23-E39	E2-E10	E22-E19
0.625	15/16	E23-E39	E1-E10	E21-E19	0.312	15/32	E23-E39	E2-E11	E22-E20

Table 5-13. 12-457G FM Reproduce Amplifier Jumper Configuration for Wide Band Group I

INTERMEDIATE BAND									
FILTER NO. 1					FILTER NO. 2				
SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN	SIGNAL FREQ (kHz)	TAPE SPEED (ips)		CENTER FREQ	GAIN
20	60	E24-E33	E1-E5	E21-E12	10	30	E23-E34	E2-E6	E22-E13
10	30	E24-E34	E1-E6	E21-E13	5	15	E23-E35	E2-E7	E22-E14
5	15	E24-E35	E1-E7	E21-E14	2.5	7-1/2	E23-E36	E2-E8	E22-E15
2.5	7-1/2	E24-E36	E1-E8	E21-E15	1.25	3-3/4	E23-E37	E2-E9	E22-E16
1.25	3-3/4	E24-E37	E1-E9	E21-E16	0.625	1-7/8	E23-E38	E2-E10	E22-E17
0.625	1-7/8	E24-E38	E1-E10	E21-E17	0.312	15/16	E23-E39	E2-E11	E22-E18
0.312	15/16	E24-E39	E1-E11	E21-E18	--	--	---	---	---

Table 5-14. 12-457G FM Reproduce Amplifier Jumper Configuration for Intermediate Band

5-30. FM RECORD AMPLIFIER 12-454A, OPERATIONAL ALIGNMENT PROCEDURES. The operational alignment procedures, with the exception of the record level adjustment, are made while in the RUN RECORD mode or with the optional REC TEST switch in the ON position. The FM record amplifier is aligned first and then the FM reproduce amplifier. Test equipment setup for the FM record amplifier alignment procedures is illustrated in figure 5-9. The carrier frequencies and deviation limits for IRIG Low Band, IRIG Intermediate Band, IRIG Wide Band Group I, and IRIG Extended Wide Band Group I are listed in table 5-15.

5-31. CENTER FREQUENCY ADJUSTMENT. The center frequency may be adjusted using the procedure below. Refer to figure 5-9.

a. Place the REC TEST switch in the ON position or enter the RUN RECORD mode.

b. Remove the input signal from the FM record amplifier.

c. Connect the counter to TP3 (yellow) on the FM record amplifier.

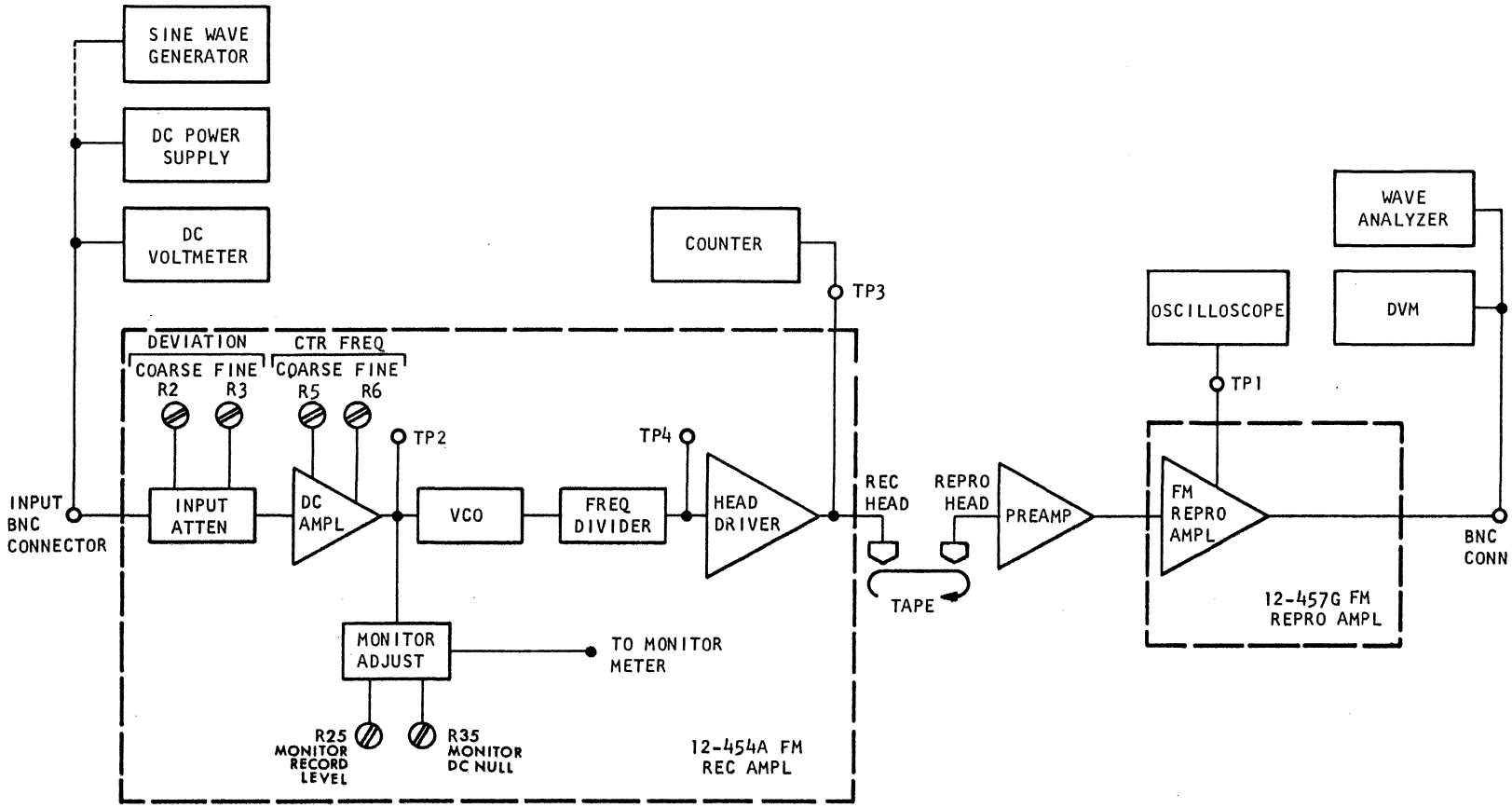


Figure 5-9. Test Setup for the 12-454A FM Record Amplifier Operational Adjustments

IRIG LOW BAND TAPE SPEED (ips)	IRIG INTERMEDIATE BAND TAPE SPEED (ips)	IRIG WIDE BAND GROUP I TAPE SPEED (ips)	IRIG EXTENDED WIDE BAND GROUP I TAPE SPEED (ips)	CARRIER CENTER FREQ (kHz)	CARRIER PLUS 40% DEVIATION (kHz)	CARRIER MINUS 40% DEVIATION (kHz)
--	--	--	120	864	1209.6	518.4
--	--	120	60	432	604.8	259.2
--	120	60	30	216	302.4	129.6
120	60	30	15	108	151.2	64.8
60	30	15	7-1/2	54	75.6	32.4
30	15	7-1/2	3-3/4	27	37.8	16.2
15	7-1/2	3-3/4	1-7/8	13.5	18.9	8.1
7-1/2	3-3/4	1-7/8	16/16	6.75	9.45	4.05
3-3/4	1-7/8	15/16	15/32	3.375	4.725	2.025
1-7/8	15/16	15/32	--	1.688	2.363	1.013
--	--	--	--	--	--	--

Table 5-15. Center Frequency and Deviation Limits, IRIG Low Band, IRIG Intermediate Band, IRIG Wide Band Group I, and IRIG Extended Wide Band Group I

d. Set the tape speed switch on the transport control panel to 60 ips or highest available speed.

e. Adjust the center frequency controls, CFc (R5, coarse) and/or CFf (R6 fine), to the center frequency ±100 Hz. See table 5-15 for the center frequency of each tape speed in each band. Example: Wide Band Group I, 60 ips; adjust CFc (R50 and/or CFf (R6) for 216 kHz ±100 Hz at TP3.

f. Check all tape speeds and verify that the correct center frequency for each speed, as stated in table 5-15, is observed at TP3.

NOTE

Perform the following steps only after center frequency is adjusted.

g. Maintain zero signal input, connect dc meter to circuit card pin 19, and adjust potentiometer R35 for 0 volts (or alternately to compensate for any dc offset in incoming signal).

5-32. DEVIATION ADJUSTMENT. Adjustment of the frequency deviation for a given input signal may be accomplished by using the following procedure. Refer to figure 5-9.

a. Place the REC TEST switch in the ON position.

b. Center frequency adjustment must be accomplished before attempting the deviation adjustment.

c. Connect the dc power supply and the dc voltmeter to the input of the FM record amplifier. (Counter connected to TP3.)

d. Set the output voltage of the power supply to the peak positive voltage of the calibration signal.

NOTE

The calibration signal is defined as the normal maximum signal level that will be applied to a given channel in the system. This level can range between 0.5 and 10 volts peak-to-peak. The level of the calibration signal should equal the maximum level of the signal which will be used subsequently in actual operation.

e. Adjust the deviation controls, ΔFc (R2, coarse) and/or ΔFf (R3, fine) to the plus deviation frequency for 60 ips. See table 5-15 for the plus and minus deviation frequencies of each tape speed in each band. Example: Wide Band Group I, 60 ips; adjust ΔFc (R2) and/or ΔFf (R3) for 302.4 kHz ±100 Hz for the plus deviation frequency.

f. Reverse the polarity of the calibration signal, keeping the voltage level the same as in step d, and check the minus deviation. Deviation should be within ±0.5 percent of the figures listed in table 5-15.

NOTE

Adjust Monitor Record Level (R25) only after deviation sensitivity (R2, R3) is finally adjusted.

g. With calibration signal (deviation sensitivity adjusted) input, adjust Monitor Record Level (R25) for record monitor output (pin 19) of 140 mV dc.

h. Disconnect the dc power supply, dc voltmeter, and counter.

i. Place the REC TEST switch in the OFF position.

5-33. RECORD LEVEL ADJUSTMENT. The normal record level for the FM record amplifier may be adjusted using the following procedure. Refer to figure 5-9. (Final adjustment should not be attempted until the FM reproduce amplifier is properly adjusted.)

a. Install a reel of bulk-erased tape on the transport.

b. Connect a wave analyzer to the output of the FM reproduce amplifier.

c. Select the highest tape speed for which low-pass filters are installed in the FM reproduce amplifier.

d. Connect a sine wave generator to the input of the FM record amplifier.

e. Set the sine wave generator to the frequency listed in table 5-16 for the tape speed selected in step c.

f. Set the generator amplitude to the peak-to-peak value corresponding to full-scale deviation.

g. Place the transport in the record mode by simultaneously pressing the REC and RUN pushbuttons.

h. Adjust the HEAD CURRENT control (R37 on the FM record amplifier) for minimum second harmonic distortion.

i. Stop the transport, turn off the system power.

j. Disconnect the test equipment.

TAPE SPEED (ips)					
LOW BAND	INTERMEDIATE BAND	WIDE BAND GROUP I	EXTENDED WIDE BAND GROUP I	FREQUENCY (kHz)	SECOND HARMONIC (kHz)
--	--	--	60	24.0	48.0
--	--	60	30	12.0	24.0
--	60	30	15	6.0	12.0
60	30	15	7-1/2	3.0	6.0
30	15	7-1/2	3-3/4	1.5	3.0
15	7-1/2	3-3/4	1-7/8	0.75	1.5
7-1/2	3-3/4	1-7/8	15/16	0.375	0.75
3-3/4	1-7/8	15/16	--	0.1875	0.375
1-7/8	15/16	15/32	--	0.09375	0.1875

Table 5-16. FM Record Level Set Frequencies, IRIG Low Band, IRIG Intermediate Band, IRIG Wide Band Group I, and IRIG Extended Wide Band Group I

5-34. DC OFFSET ADJUSTMENT. If the data signal to be recorded contains a dc component which is not desired on the recording, it is possible to offset the carrier center frequency to compensate for this dc component as follows:

a. Place the REC TEST switch in the ON position.

b. Center frequency and deviation adjustments must be accomplished before attempting the dc offset adjustment.

c. Connect the dc power supply and the dc voltmeter to the input of the FM record amplifier. Connect the counter to TP3.

d. Set the output voltage of the dc power supply to the offset voltage of the same polarity as that expected in the data signal.

e. Set the tape speed switch on the transport control panel to 60 ips or the highest tape speed for which low-pass filters are installed in the FM reproduce amplifier.

f. Adjust the CENTER FREQ control, CFc (R5, coarse) and/or CFf (R6, fine) to the center frequency $\pm$100 Hz for a tape speed of 60 ips. See table 5-15 for the center frequency of each tape speed in each band.

g. Remove all test equipment.

h. Place the REC TEST switch in the OFF position.

5-35. FM RECORD AMPLIFIER 12-454B, OPERATIONAL ALIGNMENT PROCEDURES. The operational alignment procedures, with the exception of the record level adjustment, are made while in the RUN RECORD mode or with the optional REC TEST switch in the ON

position. The FM record amplifier is aligned first and then the FM reproduce amplifier. Test equipment setup for the FM record amplifier alignment procedures is illustrated in figure 5-10. For bandwidth selection, place switch S2 on the circuit card to the appropriate position. Switch position 1 is for Extended Wide Band I, switch position 2 is for Wide Band I, and switch position 3 is for Intermediate Band.

5-36. PLUS 5 VOLT REGULATOR ADJUSTMENT. Refer to figure 5-10 (adjustment will not be required unless circuit components are changed).

a. Place the REC TEST switch in the ON position.

b. Connect the dc voltmeter to TP5.

c. Check for 5.000V $\pm$ 0.010V.

1. Adjust the 5 V STAB control R80 for 5.000 V $\pm$0.010 V if required (factory adjustment).

5-37. INPUT STAGE OFFSET ADJUSTMENTS (adjustment will not be required unless circuit components are changed).

a. Place the REC TEST switch in the ON position.

b. Connect dc voltmeter to pin 6 of IS1.

c. Short input pin to ground.

d. Check Input Stage Offset No. 1 for an indication of 0 V $\pm$10 mV on dc voltmeter.

1. Adjust Input Stage Offset No. 1 Control R6 if required (factory adjustment).

e. Set Attenuator switch to 0 or CF position.

f. Connect dc voltmeter to TP6.

g. Check Input Stage Offset No. 2 for an indication of 0 V $\pm$ 10 mV.

1. Adjust Input Stage Offset No. 2 Control R13 for an indication of 0 V $\pm$10 mV on dc voltmeter if required (factory adjustment).

h. Set Attenuator switch to 0.1 volt position.

i. Readjust R13 for 0 V $\pm$10 mV on dc voltmeter if required.

j. Set Attenuator switch to 0 or CF position.

k. Check dc voltmeter reading for 0 V $\pm$10 mV. If not within specification, repeat step d.1.

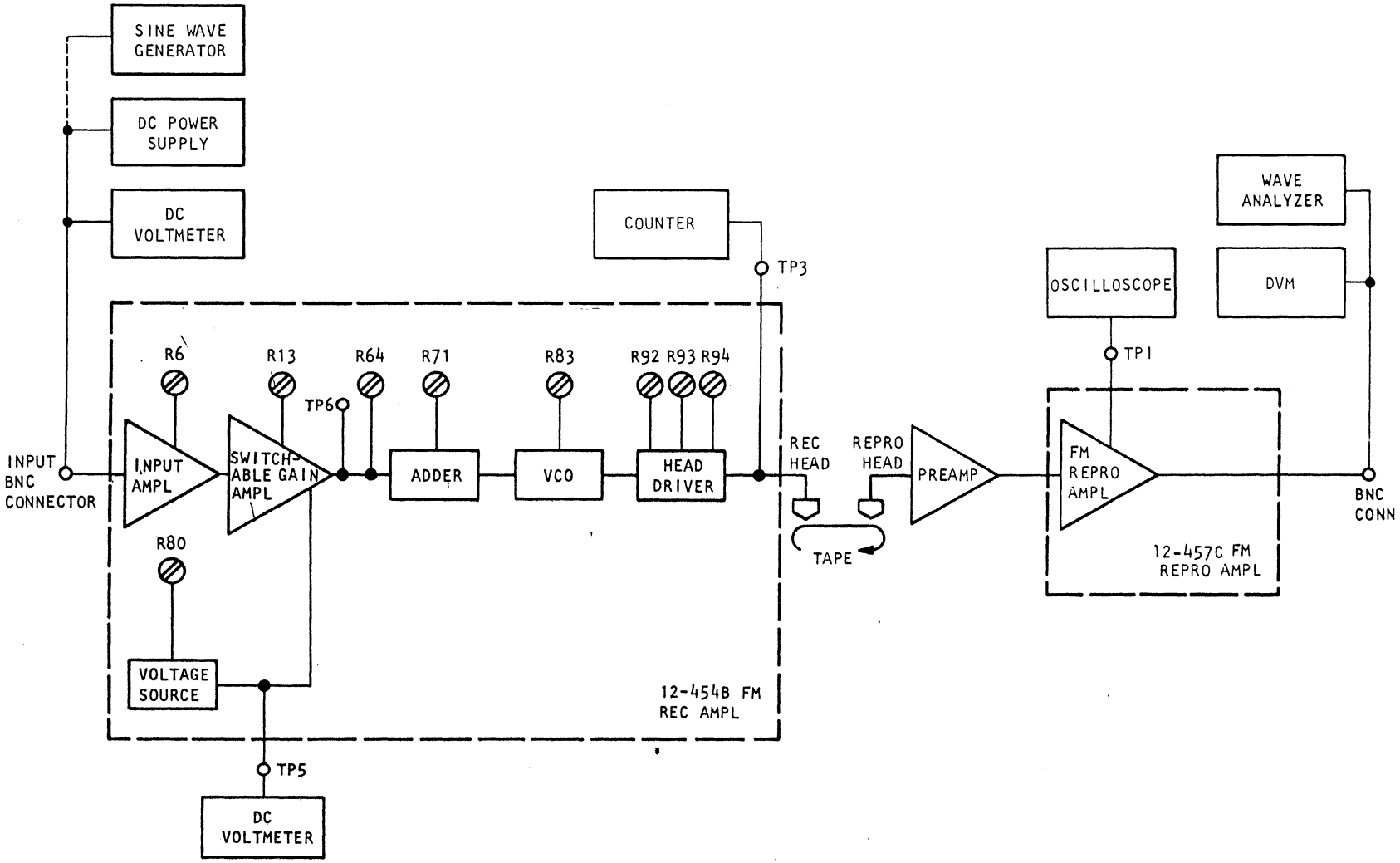


Figure 5-10. Test Setup for the 12-454B FM Record Amplifier Operational Adjustments

5-38. CENTER FREQUENCY ADJUSTMENT. The center frequency may be adjusted using the procedure below. Refer to figure 5-10.

a. Place the REC TEST switch in the ON position or enter the RUN RECORD mode.

b. Set attenuator switch to 0 of CF position.

c. Connect the counter to TP3 on the FM record amplifier.

d. Set the tape speed switch on the transport control panel to 30 ips for Intermediate Band, 15 ips for Wide Band, or 7-1/2 ips for Extended Wide Band.

e. Adjust the center frequency controls, CFc (R71, coarse) and/or CFf (R83, fine), to the center frequency ±100 Hz. See table 5-15 for the center frequency of each tape speed in each band. Example Wide Band Group I, 15 ips; adjust CFc (R71) and/or CFf (R83) for 54 kHz ±100 Hz at TP3.

f. Check all tape speeds and verify that the correct center frequency for each speed, as stated in table 5-15, is observed at TP3.

5-39. DEVIATION ADJUSTMENT. Adjustment of the frequency deviation for a given input signal may be accomplished by using the following procedure. Refer to figure 5-10.

a. Place the REC TEST switch in the ON position.

b. Center frequency adjustment must be accomplished before attempting the deviation adjustment.

c. Set attenuator switch to ΔF position (counter connected to TP3).

d. Adjust the deviation control ΔF (R64), to the plus deviation frequency for 15 ips. See table 5-15 for the plus and minus deviation frequencies of each tape speed in each band. Example: Wide Band Group I, 15 ips; adjust ΔF (R64) for 75.6 kHz ±100 Hz for the plus deviation frequency.

5-40. RECORD LEVEL ADJUSTMENT. The normal record level for the FM record amplifier may be adjusted using the following procedure. Refer to figure 5-10. (This final adjustment should not be attempted until the FM reproduce amplifier is properly adjusted according to paragraphs 5-50 through 5-56.)

a. Install a reel of bulk-erased tape on the transport.

b. Connect a wave analyzer to the output of the FM reproduce amplifier.

c. Select 60 ips.

d. Connect a sine wave generator to the input of the FM record amplifier.

e. Set the sine wave generator to the frequency listed in table 5-17 for a tape speed of 60 ips.

f. Set the generator amplitude to the RMS value corresponding to full-scale deviation.

g. Place the transport in the record mode by simultaneously pressing the REC and RUN pushbuttons.

h. Adjust the appropriate HEAD CURRENT control for selected band of operation (R92 through R94 on the FM record amplifier) for best signal-to-noise ratio (see table 5-17).

i. Stop the transport; turn off the system power.

j. Disconnect the test equipment.

TAPE SPEED (ips)					
LOW BAND	INTERMEDIATE BAND (R94)	WIDE BAND GROUP I (R93)	EXTENDED WIDE BAND GROUP I (R92)	FREQUENCY (kHz)	SECOND HARMONIC (kHz)
--	--	--	120	48.0	96.0
--	--	120	60	24.0	48.0
--	120	60	30	12.0	24.0
--	60	30	15	6.0	12.0
60	30	15	7-1/2	3.0	6.0
30	15	7-1/2	3-3/4	1.5	3.0
15	7-1/2	3-3/4	1-7/8	0.75	1.5
7-1/2	3-3/4	1-7/8	15/16	0.375	0.75
3-3/4	1-7/8	15/16	15/32	0.1875	0.375
1-7/8	15/16	15/32	--	0.09375	0.1875

Table 5-17. FM Record Level Set Frequencies, IRIG Low Band, IRIG Intermediate Band, IRIG Wide Band Group I, and IRIG Extended Wide Band Group I

5-41. 12-457G FM REPRODUCE AMPLIFIER ALIGNMENT PROCEDURE. Test equipment placement for the FM reproduce amplifier alignment procedures is illustrated in figure 5-11. Unless otherwise specified, reference to the highest tape speed means the highest tape speed for which the amplifier is wired and for which filters are installed.

5-42. Bandwidth Selection. Either IRIG Intermediate Band, IRIG Wide Band Group I, or IRIG Extended Wide Band Group I may be selected by making the appropriate

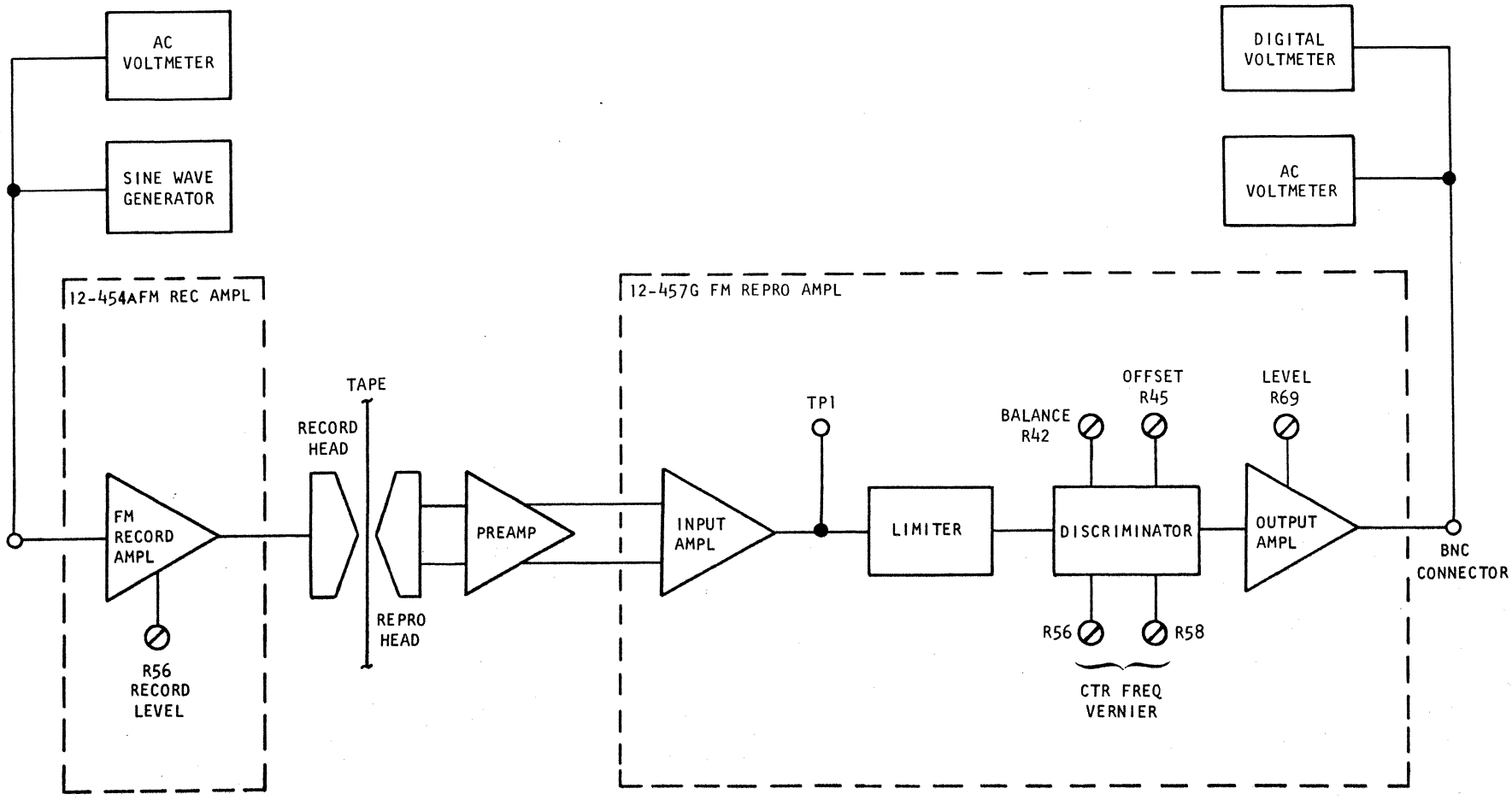


Figure 5-11. 12-457G FM Reproduce Amplifier Alignment Procedure

jumper connections on the FM reproduce amplifier. If a different bandwidth is desired, refer to tables 5-12 through 5-14 for the proper jumper configurations for each band.

5-43. Filter Selection. Due to space restrictions, only two 13-560-XX Filters can be mounted on a 12-457G FM Reproduce Amplifier circuit card at any one time. Therefore, only two tape speeds are usable with any given FM amplifier channel. The appropriate filters must be installed for the desired tape speeds and bandwidth. Refer to table 5-18 for the proper filter selection information.

5-44. The output response of each of the 13-560-XX Filters is selectable for either a flat or an optimized transient response by means of a switch located on the filter itself. Figure 5-12 shows the waveforms for each switch position.

TAPE SPEED (ips)				
IRIG INTERMEDIATE BAND	IRIG WIDE BAND GROUP I	IRIG EXTENDED WIDE BAND GROUP I	FILTER TYPE	BANDWIDTH (kHz)
--	--	60	13-560-11	80
--	60	30	13-560-12	40
60	30	15	13-560-13	20
30	15	7-1/2	13-560-14	10
15	7-1/2	3-3/4	13-560-15	5
7-1/2	3-3/4	1-7/8	13-560-16	2.5
3-3/4	1-7/8	15/16	13-560-17	1.25
1-7/8	15/16	--	13-560-18	0.625
15/16	15/32	--	13-560-19	0.312

Table 5-18. Filter Selection for IRIG Intermediate Band, IRIG Wide Band Group I, and IRIG Extended Wide Band Group I

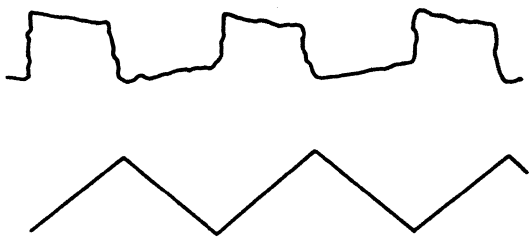


Figure 5-12. Filter Input Voltage Waveforms

5-45. The adjustment procedures for the FM reproduce amplifier may be accomplished by moving tape, or by using the RCD TEST switch located on the front panel of the optional monitor meter. It is necesary that the FM record amplifier be previously adjusted. An extender card is required to gain access to BALANCE control (R42), center frequency vernier controls (R56 and R58), and TP2. Proceed with the following:

CAUTION

Turn system power OFF before removing or replacing a circuit card in an amplifier case.

a. With no signal applied, place the transport in the highest speed of the two filters in the FM reproduce amplifier and place in the RECORD mode (or place the RCD TEST switch in the ON position). The filter with the highest bandwidth will be in the FL1 position.

b. Connect the wave analyzer to TP2 of the FM reproduce amplifier. With the filter switched to flat response, adjust the wave analyzer to the center frequency of the highest programmed speed.

c. Adjust R42, BALANCE control, for a minimum indication on the wave analyzer at the center frequency.

d. Adjust the wave analyzer to four times the center frequency. Adjust R56, center frequency vernier for the highest speed, for the minimum indication on the wave analyzer.

e. Connect the digital voltmeter to the output of the FM reproduce amplifier and adjust R45, DC OFFSET, for 0 volts $\pm$7 mV.

f. Select the lower programmed tape speed and adjust R58, center frequency vernier for the lower speed, for 0 volts $\pm$7 mV. Disconnect the digital voltmeter.

g. Place the RCD TEST switch (if used) in the OFF position.

h. Connect a sine wave generator to the input of the FM record amplifier and record a calibration signal at 10 percent band edge for the highest selected tape speed. Connect an ac voltmeter to the output of the reproduce amplifier.

NOTE

A calibration signal is defined as the normal maximum signal level that will be applied to a given channel in a system. This level should equal the maximum level of the signal to be used during actual operation.

i. Adjust R69, LEVEL control, in the FM reproduce amplifier for 1 V rms on the ac voltmeter.

j. Press the STOP pushbutton and remove all test equipment. Remove power and return the circuit card to its normal position in the amplifier case assembly.

5-46. 12-458 UNIVERSAL FM REPRODUCE AMPLIFIER ALIGNMENT PROCEDURES.

5-47. BANDWIDTH SELECTION. Place switch, S1, on the circuit card to the appropriate position for the bandwidth required. Switch position 1 is for Wide Band Group I, switch position 2 is for Intermediate Band, and switch position 3 is for Low Band.

5-48. FILTER SELECTION. Place switch, S2, on the circuit card to the appropriate filter response required. Switch position 4 is for the Butterworth (flat) filter, and switch position 5 is for the Bessel (transient) filter.

5-49. To adjust the 12-458 Universal FM Reproduce Amplifier, proceed as follows

a. Ensure that the other portion of switch S2 (flutter compensation) is in the off position (position 3).

b. Connect a digital voltmeter to the output of the FM reproduce amplifier.

c. With no signal applied, place the transport in the RECORD mode at the speed that is being used.

d. Adjust the dc offset controls, R58 coarse, and R57 fine, for 0 volts $\pm$7 mV.

e. Connect a sine wave generator to the input of the FM record amplifier and record a calibration signal at 10 percent band edge for the tape speed being used.

f. Connect an ac voltmeter to the output of the FM reproduce amplifier.

g. Adjust the level control, R59, on the universal FM reproduce amplifier for 1 V rms output.

h. Stop the transport, turn off system power, and remove all test equipment.

5-50. 12-457C UNIVERSAL FM REPRODUCE AMPLIFIER ALIGNMENT PROCEDURES.

5-51. BANDWIDTH SELECTION. Place switch, S2, on the circuit card to the appropriate position for the bandwidth required. Switch position 1 is for Intermediate Band, switch position 2 is for Wideband Group I, and switch position 3 is for Extended Wideband Group I.

5-52. FILTER SELECTION. Place switch, S1, on the circuit card to the appropriate filter response required. When viewed from the front of the circuit card, the upper switch position 1 is for the Butterworth (flat) filter, and the lower switch position 2 is for the Bessel (transient) filter.

5-53. To adjust the 12-457C Universal FM Reproduce Amplifier, proceed as follows.

5-54. FIRST STAGE GAIN ADJUSTMENT. (See figure 5-13.)

a. Connect digital voltmeter to TP1.

b. Adjust Head Current control R98 for 200 mV p-p with center frequency recorded on tape.

5-55. SPEED OFFSET ADJUSTMENT.

a. Set transport to RECORD-TEST mode at 1-7/8 ips at center frequency for Wide Band Group I operation.

b. Set to 0 Vdc output with DC OFS controls at the output of the FM reproduce amplifier.

c. Switch to 60 ips.

d. Adjust Speed Offset control R73 for 0 Vdc output.

5-56. DC OFFSET AND LEVEL ADJUSTMENT.

a. Connect a digital voltmeter to the output of the FM reproduce amplifier.

b. With no signal applied, place the transport in the record mode at the speed that is being used.

c. Adjust the dc offset controls, R79, coarse, and R80, fine, for 0 volts $\pm$7 mV.

d. Set attenuator switch S1, to the ΔF position.

e. Connect an ac voltmeter to the output of the FM reproduce amplifier.

f. Adjust the level control, R87, on the universal FM reproduce amplifier for 1 V rms output.

g. Final record level adjustment should now be performed according to paragraph 5-40.

h. Stop the transport, turn off system power, and remove all test equipment.

5-57. PLUG-IN FM CALIBRATOR ALIGNMENT PROCEDURES.

5-58. The optional 12-455 Plug-in FM Calibrator is used for alignment of the FM record/reproduce amplifiers. Refer to the operation and maintenance manual of the FM Calibrator, Section III, for the alignment procedures when using the optional plug-in calibrator. The procedures contained therein are detailed and include the adjustment procedures of center frequency, deviation sensitivity, and record head current of the FM record amplifier; and the DC OFFSET, LEVEL, and BALANCE controls of the FM reproduce amplifier.

5-59. The alignment procedures for using the plug-in FM calibrator may be used in lieu of, or as a supplement to, the alignment procedures given in the above paragraphs 5-30 through 5-56.

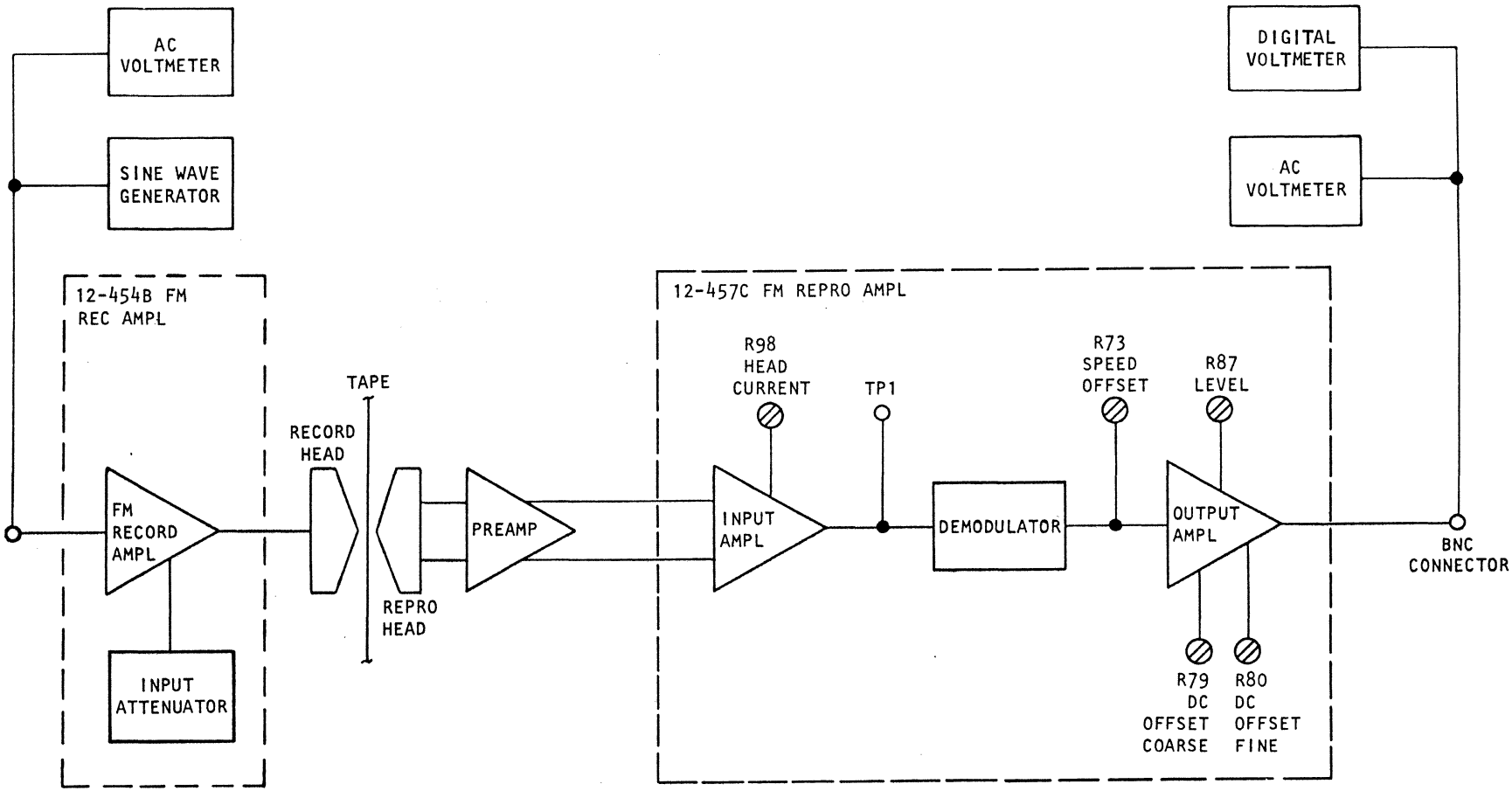


Figure 5-13. 12-457C FM Reproduce Amplifier Alignment Procedure

5-60. TROUBLESHOOTING.

5-61. Troubleshooting procedures are necessary when a mechanical or electrical fault is present. The discussion of system troubleshooting is restricted to suggestion or techniques for pinpointing trouble to a particular assembly. Once the faulty component is located, normal troubleshooting procedures can be found in the individual manual for that assembly. The following paragraphs suggest a few possible locations for causes of various symptoms.

5-62. Troubles in a magnetic tape recording/reproducing system are of four types.

a. Troubles affecting tape movement. A suggested procedure for troubleshooting the capstan servo circuit is found in Section V of the transport manual.

b. Troubles affecting the data recorded or reproduced.

c. Troubles affecting the auxiliary functions of the system.

d. Troubles which are not apparent during normal operation but are indicated by failure of the equipment to respond properly to adjustment.

5-63. TAPE MOVEMENT FAULTS. Table 5-19 lists common tape movement faults and possible causes.

SYMPTOMS	POSSIBLE CAUSES
No tape movement	1. Tape not properly threaded. 2. Inadequate tape tension. 3. Faulty tension sensor phototransistor. 4. Faulty diode in the tension sensor assembly. 5. Faulty control logic. 6. Faulty reel or capstan. 7. Faulty end-of-tape circuit. 8. RECORD TEST switch is on. 9. If a remote control unit is used, faulty remote control unit or intercable connections. 10. If remote control is not used, speed selector switch is in the remote (R) position.

Table 5-19. Tape Movement Faults and Possible Causes (Sheet 1 of 2)

SYMPTOMS	POSSIBLE CAUSES
Sluggish tape movement	1. Faulty motors or speed control circuit.
	2. Faulty brake.
Tape movement at wrong speed	1. Faulty speed selection circuit.
	2. Faulty gate circuit in control logic board.
Excessive speed in any run mode	1. Faulty capstan motor or associated power or control circuit.
Tape not winding properly onto takeup reel	1. Faulty takeup reel motor or associated power or control circuit.
Inaccurate speed or varying speed in run mode	1. Faulty speed control servo.
Loop-throwing on starting any RUN or FAST mode	1. Reel servo control misalignment.
Faulty tape stacking in any mode	1. Faulty reel or reels or faulty reel servo circuit.
	2. Faulty tape.
	3. Guides not properly aligned.
Tape tension is lost when going to STOP	1. Capstan servo gain improperly adjusted.

Table 5-19. Tape Movement Faults and Possible Causes (Sheet 2 of 2)

5-64. SIGNAL FAULTS. Table 5-20 lists common signal faults and possible causes.

5-65. FAULTS IN AUXILIARY FUNCTIONS. For information regarding the location of faults in the monitor meter, voice logging unit, tape servo control unit, remote control unit, or the bin loop adapter, see the corresponding operation and maintenance manual.

SYMPTOMS	POSSIBLE CAUSES
No signal or weak signal	1. Dirty heads. 2. Faulty head (open winding, shorted gap). 3. Faulty preamplifier or amplifier. 4. Faulty signal wiring. 5. Faulty power wiring. 6. Faulty monitor equipment (giving indication of no signal or weak signal when signal is actually normal).
Dropouts of portions of signal	1. Dirty tape. 2. Dirty heads.
Distorted signal (even harmonic distortion)	1. Magnetized head or guide.
Periodic distortion or interference (synchronized with rotation of roller)	1. Magnetized roller.
Noise (on FM data)	1. Flutter in tape transport.
Other noise	1. Faulty preamplifier, amplifier, or signal wiring. 2. Spurious signal originating in tape transport or elsewhere, because of arcing, loose connections, cold solder joints, faulty switch or relay, open capacitor or diode, or oscillating amplifier.

Table 5-20. Signal Faults and Possible Causes

5-66. FAULTS REVEALED DURING ADJUSTMENT. Table 5-21 lists common adjustment faults and possible causes.

SYMPTOMS	POSSIBLE CAUSES
Adjustment of equalization has no effect at one or more speeds	1. Speed selector equalizer switching faulty. 2. Wrong filter installed on FM reproduce amplifier.
Adjustment of equalization for one or more tracks cannot produce adequate high frequency response	1. Dirty heads. 2. Head gaps have opened (head must be replaced).

Table 5-21. Adjustment Faults and Possible Causes

5-67. TROUBLESHOOTING RECORD/REPRODUCE CIRCUITS. Trouble in these circuits frequently may be located by tracing signals and power supply voltages. Signal flow through the system can be traced by applying an input signal and measuring the output signal from each amplifier while simultaneously recording and reproducing data. The record signal waveform can be observed with an oscilloscope at the head current motor terminals on the amplifier. Outputs of reproduce amplifiers can be observed with an oscilloscope at the BNC connectors on the front panel. For the proper amplitudes and waveforms in the various types of record and reproduce amplifiers, see the adjustment procedures in the individual manual for the amplifier. The following list (a through e) describes possible symptoms and solutions for this system:

NOTE

Do not interchange amplifiers indiscriminately. If amplifiers are interchanged as a troubleshooting check, always return the amplifiers to the original channels from which they were removed. The amplifiers are adjusted at the factory for optimum operation with the magnetic head in the channel into which the amplifiers are installed. Interchanging or mixing the amplifiers may necessitate complete readjustment of the channels involved.

CAUTION

Do not remove or replace any component with system power on.

a. If the record or reproduce signal is absent in a particular channel, try substituting another amplifier from a channel which is working properly.

b. If the second amplifier fails to produce a signal, check the connector in the amplifier case, its wiring, the head cabling, head connector, and the head itself.

c. If the fault is in one channel only, first check to see that the operational voltages are present within the amplifiers tried in that channel.

d. If the operational voltages are normal, check the signal path circuitry.

CAUTION

Do not connect an ohmmeter directly across the windings of a magnetic head or any circuit with a dc connection to the head. Even if the current from the meter is not sufficient to harm the winding, the presence of the dc will magnetize the head. If dc has been accidentally introduced into the winding of the head, degauss the head before further use.

e. If all the amplifiers fail to work, look for failure of the transport power supply.

5-68. MAGNETIZED HEADS. Magnetized heads have adverse effects on direct recording. The presence of a dc element in the record signal degrades the signal-to-noise ratio by production of excessive noise. The dc element also works to shift the operating center of the magnetic recording process so that the recordings are made on a non-linear part of the magnetization curve, and excessive distortion of recorded signals may be produced.

5-69. MAGNETIZED ROLLERS OR CAPSTAN SHAFT. Magnetized rollers can cause serious deterioration of the signal-to-noise ratio of the direct record/reproduce system. If a magnetic field from a magnetized roller is turned (by passage of tape) so that its flux cuts across the gap of the reproduce head, a noise signal is created.

5-70. It is possible for the capstan shaft to become magnetized during demagnetization of the heads. With a magnetized capstan, the sensitivity of the reproduce heads is such that unwanted signals may be induced into them originating from the magnetized capstan.

5-71. DEGAUSSING PROCEDURE. Magnetized components may be degaussed as follows:

a. System power should be turned off and capstan rotation stopped.

b. Degauss the capstan, the rollers, and the four heads.

c. With a circular motion, slowly pull the degausser away from the transport.

NOTE

Do not turn the degausser off until it is at least three feet away from the heads. Another method of making sure that the collapsing field of the degausser does not remagnetize the heads is to also turn the degausser 90 degrees away from the transport before turning the power off.

d. If checks show that some of the tape handling components are still magnetized, repeat the above procedures. In some instances components may have to be removed and degaussed on a bulk degausser.

5-72. HARD-TO-TRACE TROUBLES. Occasionally, an equipment defect will not produce any noticeable direct effects, but will produce an indirect effect which is hard to trace back to the original fault. If the trouble is unfamiliar, and if logical analysis does not provide any useful leads, check to see if there is anything abnormal in any of the other sections, even those which have no apparent logical connection with the trouble. Sometimes, in such a case, the explanation for a trouble becomes apparent only after the cause has been found. The checking should be as direct and conclusive as possible. Use signal tracing, voltage and resistance measurement, and other functional and component tests in electrical and electronic circuits. For mechanical parts, and where appropriate, for electrical ones, use sight, hearing, and other senses to obtain indications on how the parts are actually functioning. Stroboscopes, sound amplifiers, and other supplements to the senses sometimes can be used profitably.

5-73. FUSES. A blown fuse can be a symptom of trouble elsewhere; replace the fuse once; if the circuit opens a second time, look for the primary cause of the trouble. Section III of this manual lists the location and size of each fuse used in the system.

5-74. REPAIR.

5-75. Repair of this magnetic tape record/reproduce equipment should be undertaken only by technicians experienced in the maintenance of instrumentation grade tape equipment. The printed circuit boards should be repaired only by personnel experienced in printed wiring techniques. It is recommended that repair be limited to replacement of defective components and adjustment of controls.

5-76. Be sure that replacement parts are of the correct type and value, and that they are known to be good. When removing and replacing defective components, be careful not to burn or damage the surrounding circuit parts, particularly on printed circuit boards. When installing a new part, place it in the exact position as the one replaced and, after replacement, inspect the circuit board for evidence of cold solder joints, solder splashes, and insecurity of mounting.

5-77. EXTENDER CARD. An extender card is provided with the system to provide access to the record and reproduce electronics circuit boards. When using the extender card, orient it so that its pins will mate with its connector properly and push it firmly into the connector. Then, with power off, install the circuit board being tested into the extender card.

5-78. FIELD REPAIR SERVICE.

5-79. Regular scheduled maintenance service is available from the Bell & Howell DATATAPE Division Sales and Service Office on a contract basis. If immediate service is required, it may be obtained on an emergency basis. Every effort is made to furnish the needed repair as soon as possible. For a complete description of Bell & Howell's maintenance service plans and their costs, contact the DATATAPE Division Sales and Service Office nearest you.

5-80. FACTORY REPAIR SERVICE.

5-81. If desired, component parts or major assemblies may be returned to the factory for repair, accompanied by the following information:

a. Indicate any symptom or defect. State as completely as possible, both on an instrument tag and on your order, the nature of the problem. If the trouble is intermittent, please be specific in your description of the instrument's performance history.

b. Give special instructions. If you have made any change in the instrument or assembly and wish us to return it to you in the same altered form, please indicate this when you submit the equipment for repair.

c. State the desired invoicing procedure. In your first correspondence, indicate whether we may begin the repair work immediately and bill you later in accordance with our standard pricing system, or whether we should secure your prior approval of the price before proceeding with the repair.

d. Pack securely and label. When packaging or crating, give special attention to the cushioning and securing of the part or instrument to prevent damage in transit. Make certain that the address is both legible and complete. Address all shipments and correspondence to:

Bell & Howell Company
DATATAPE Division
300 Sierra Madre Villa
Pasadena, California 91109

Attention: Repair Department

e. Give return address instructions. Please indicate clearly the address to which the equipment is to be returned after repair is completed. All shipping costs, to and from the factory, will be borne by the owner of the equipment, not by Bell & Howell.

SECTION VI

PARTS LIST

6-1. REPLACEMENT PARTS LIST.

6-2. Part lists for the 1/2-inch and 1-inch head assemblies, the 1/2-inch and 1-inch tape width kits, and the slide rackmounting and fixed rackmounting kits are included in this section of the manual. Part lists for the other components which may make up a 4020A system are included in the individual component manuals. The part lists give the Bell & Howell part numbers and descriptions of replaceable parts, and where applicable, the manufacturer and manufacturer's part number, or the military part number. The manufacturers are identified by the Federal Supply Code for Manufacturers, Cataloging Handbook H 4-2, and as listed in table 6-1. Figures 6-1 and 6-2 are the drawings for the rackmounting kits. Figure 6-3 is the cabling diagram.

6-3. ORDERING REPLACEMENT PARTS.

6-4. Parts should be ordered through the nearest Bell & Howell DATATAPE Division Sales and Service Office. Price and delivery information on parts or complete instruments may be obtained there also. To assist in making this contact, a list of Sales and Service Offices is included in the front of this manual. When ordering parts, the following information should be supplied to our field office engineers:

a. A description of the part or assembly, obtained from the parts list.

b. The Bell & Howell part or assembly number, also in the parts list, or on the component proper.

c. The schematic symbol, given on the cabling diagram and in the parts list.

d. The part or assembly type number, shown on the instrument nameplate.

e. The production serial number, also on the nameplate.

f. The Bell & Howell register number, applying to the complete system.

CODE	MANUFACTURER
00779	AMP, Incorporated Harrisburg, Pennsylvania
01121	Allen-Bradley Company Milwaukee, Wisconsin
01295	Texas Instruments, Incorporated Semiconductor-Components Division Dallas, Texas
02288	Allied Control Company, Incorporated Plantsville, Connecticut
02735	RCA Corporation Solid State Division Somerville, New Jersey
03508	General Electric Company Semiconductor Products Department Syracuse, New York
04713	Motorola, Incorporated Semiconductor Products Division Phoenix, Arizona
05397	Union Carbide Corporation Cleveland, Ohio
05464	Industrial Electronic Engineers, Incorporated Van Nuys, California
05574	Viking Industries, Incorporated Chatsworth, California
05972	Loctite Corporation Newington, Connecticut
06111	Fairchild Camera and Instrument Corporation Fairchild Controls Division Mountain View, California
06192	LA and Deau Manufacturing Company Los Angeles, California
06383	Panduit Corporation Tinley Park, Illinois

Table 6-1. List of Manufacturers (Sheet 1 of 7)

CODE	MANUFACTURER
06540	Amatom Electronic Hardware Division Mite Corporation New Rochelle, New York
07168	Eubanks Engineering Monrovia, California
07556	Calabro Plastics, Incorporated Upper Darby, Pennsylvania
08289	Delbert Blinn Company, Incorporated Pomona, California
09353	C & K Components, Incorporated Newton, Massachusetts
14028	Bell & Howell Company DATATAPE Division Pasadena, California
14655	Federal Pacific Electric Company Cornell-Dubilier Electronics Division Newark, New Jersey
15636	Electrol, Incorporated Saugus, California
18565	Chomerics, Incorporated Woburn, Massachusetts
19112	Garry Manufacturing Company Brunswick, New Jersey
21960	Industrial Plastics of Minneapolis Minneapolis, Minnesota
24546	Corning Glass Works Bradford, Pennsylvania
25504	Rotary Components, Incorporated Covina, California
27014	National Semiconductor Corporation Santa Clara, California
27304	Magnedyne,Incorporated Carlsbad, California

Table 6-1. List of Manufacturers (Sheet 2 of 7)

CODE	MANUFACTURER
28480	Hewlett Packard Palo Alto, California
29587	Bunker-Ramo Corporation Amphenol Industrial Division Cicero, Illinois
31433	Union Carbide Corporation Materials Systems Division Components Department Greenville, South Carolina
31471	American Micro Systems, Incorporated Santa Clara, California
32539	Mura Corporation Westbury, Long Island, New York
40920	Miniature Bearing Division MPB Corporation Keene, New Hampshire
44655	Ohmite Manufacturing Company Skokie, Illinois
46385	Penn Engineering and Manufacturing Corporation Doylestown, Pennsylvania
50088	Mostek Corporation Carrollton, Texas
56289	Sprague Electric Company North Adams, Massachusetts
71590	Globe-Union, Incorporated Centralab Electronics Division Fort Dodge, Iowa
71744	Chicago Miniature Lamp Works Chicago, Illinois
71785	TRW, Incorporated TRW Cinch Connectors Elk Grove Village, Illinois
71984	Dow Corning Corporation Midland, Michigan

Table 6-1. List of Manufacturers (Sheet 3 of 7)

CODE	MANUFACTURER
72962	Amerace Corporation ESNA Division Union, New Jersey
72982	Erie Technological Products, Incorporated Erie, Pennsylvania
73138	Beckman Instruments, Incorporated Helipot Division Fullerton, California
73559	Carling Electric, Incorporated West Hartford, Connecticut
74545	Harvey Hubbell, Incorporated Bridgeport, Connecticut
74970	E.F. Johnson Company Waseca, Minnesota
75042	TRW Electronic Components IRC Philadelphia Division Philadelphia, Pennsylvania
75237	The Kaynar Company Division of Reiner Industries, Incorporated Pico Rivera, California
75915	Littelfuse, Incorporated Des Plaines, Illinois
76493	J.W. Miller Company Compton, California
76854	Oak Manufacturing Company Division of Oak Electro/Netics Corporation Crystal Lake, Illinois
77902	Rohm and Haas Company Philadelphia, Pennsylvania
78189	Illinois Tool Works, Incorporated Shakeproof Division Elgin, Illinois
78488	Stackpole Carbon Company St. Marys, Pennsylvania

Table 6-1. List of Manufacturers (Sheet 4 of 7)

CODE	MANUFACTURER
78553	Tinnerman Products, Incorporated Cleveland, Ohio
79963	Zierick Manufacturing Company Mt. Kisco, New York
80294	Bourns, Incorporated Riverside, California
80411	Robertshaw Controls Company Arco Division Columbus, Ohio
81312	Winchester Electronics Division Litton Systems, Incorporated Oakville, Connecticut
81349	Military Specifications Promulgated by Military Departments/Agencies Under Authority of Defense Standardization Manual 4120 3-M
81350	Joint Army-Navy Specifications Promulgated by Military Departments Under Authority of Defense Standardization Manual 4120 3-M
81840	Ledex, Incorporated Dayton, Ohio
82389	Switchcraft, Incorporated Chicago, Illinois
82973	American Chain and Cable Company, Incorporated Bristol Division Los Angeles, California
83058	Carr Fastener Company United-Carr Division of TRW, Incorporated Cambridge, Massachusetts
83330	Herman H. Smith, Incorporated Brooklyn, New York
83584	Driv-Lok Sycamore, Illinois
84830	Lee Spring Company Brooklyn, New York

Table 6-1. List of Manufacturers (Sheet 5 of 7)

CODE	MANUFACTURER
86684	Radio Corporation of America Electronic Components Harrison, New Jersey
86797	Rogan Bros., Incorporated Skokie, Illinois
86928	Seastrom Manufacturing Compnay, Incorporated Glendale, California
87034	Oak Technology, Incorporated Oak Industries Switch Division Crystal Lake, Illinois
87334	ESB, Incorporated Ray-O-Vac Division Wonewoc, Wisconsin
91506	Augat, Incorporated Attleboro, Massachusetts
91637	Dale Electronics, Incorporated Columbus, Nebraska
92528	H.B. Fuller Company St. Paul, Minnesota
92830	Associated Spring Corporation Wallace Barnes Division Bristol, Connecticut
93790	Federal Pacific Electric Company Cornell-Dubilier Electronics Division New Bedford, Massachusetts
94222	Southco, Incorporated Lester, Pennsylvania
95238	Continental Connector Corporation Woodside, New York
96641	Owen Laboratories Division of Berkleonics Monrovia, California
96906	Military Standards Promulgated by Military Departments Under Authority of Defense Standardization Manual 4120-3M

CODE	MANUFACTURER
98410	ETC, Incorporated Cleveland, Ohio
98978	International Electronic Research Corporation Subsidiary of Dynamics Corporation of America Burbank, California
99800	American Precision Industries, Incorporated Delevan Electronics Division East Aurora, New York

Table 6-1. List of Manufacturers (Sheet 7 of 7)

Table 6-2. Parts List for the Head Assemblies

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	473321-0002	12-418 Record/Reproduce Head Assembly, 300 kHz, 1/2-inch	1		14028	473321-0002
2	473321-0005	12-428 Record/Reproduce Head Assembly, 300 kHz, 1-inch	1		14028	473321-0005
3	473313-0002	12-418-1 Record/Reproduce Head Assembly, 1 MHz, 1/2-inch	1		14028	473313-0002
4	473313-0005	12-428-1 Record/Reproduce Head Assembly, 1 MHz, 1-inch	1		14028	473313-0005

Table 6-3. Parts List for the 12-414A-2 Tape Width Kit

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	532140-0002	Kit, tape (spares), 1/2-inch	1		14028	532140-0002
2	212541-0002	Reel Hub	2		14028	212541-0002
3	379335-0001	Tape Tension Sensor Assembly, 1/2-inch	1		14028	379335-0001
4	379335-0002	Tape Tension Sensor Assembly, 1/2-inch	1		14028	379335-0002
5	476162	Damper, roller assembly, 1/2-inch	1		14028	476162
6	535561-0002	Roller Kit, tape guide, 1/2-inch	4		14028	535561-0002

Table 6-4. Parts List for the 12-414A-5 Tape Width Kit

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	532140-0005	Kit, tape (spares), 1-inch	1		14028	532140-0005
2	212541-0005	Reel Hub	2		14028	212541-0005
3	379335-0003	Tape Tension Sensor Assembly, 1-inch	1		14028	379335-0003
4	379335-0004	Tape Tension Sensor Assembly, 1-inch	1		14028	379335-0004
5	476161	Damper, roller assembly, 1-inch	1		14028	476161
6	535561-0005	Roller Kit, tape guide, 1-inch	4		14028	535561-0005

Table 6-5. Parts List for the Included Essential Spares and Accessories

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	532718	Spares and Accessories	1		14028	532718
2	472843	Key, head adj	1		14028	472843
3	204790-0004	Cable Assembly	1		14028	204790-0004

Table 6-6. Parts List for the 12-480-1 Slide Rackmounting Kit (Sheet 1 of 2)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY -7	QTY -14	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	518250-0022	Kit, slide mtg (4020A, 7-channel)	1	-		14028	518250-0022
2	518250-0025	Kit, slide mtg (4020A, 14-channel)	-	1		14028	518250-0025
3	518778	Installation Dwg	1	1	6-1	14028	518778
4	518251	Chassis, transport mtg	1	1	6-1/1	14028	518251
5	518392	Plate, cable holder	1	1	6-1/3		
6	518616-0018	Slide	1 pr	1 pr	6-1/24		
7	518616-0001	Bracket, front	2	2	6-1/25		
8	518253	Bracket, slide mtg	2	2	6-1/4		
9	518252	Cover, chassis	1	1	6-1/2		
10	127938-2311	Stud, self-locking	7	7			
11	471147-0009	Fastener, panel	2	2	6-1/7		
12	248363-0001	Fastener, pawl	2	2	6-1/6		
13	518522	Nut Bar	2	2	6-1/9		
14	518217	Block, hinge	2	2	6-1/5		
15	250005	Nut Bar	4	4	6-1/8		
16	126732-0056	Connector BNC	7	14			
17	175431-0213	Screw, pan hd, 4-40 x 1/4	7	7	6-1/10		

Table 6-6. Parts List for the 12-480-1 Slide Rackmounting Kit (Sheet 2 of 2)

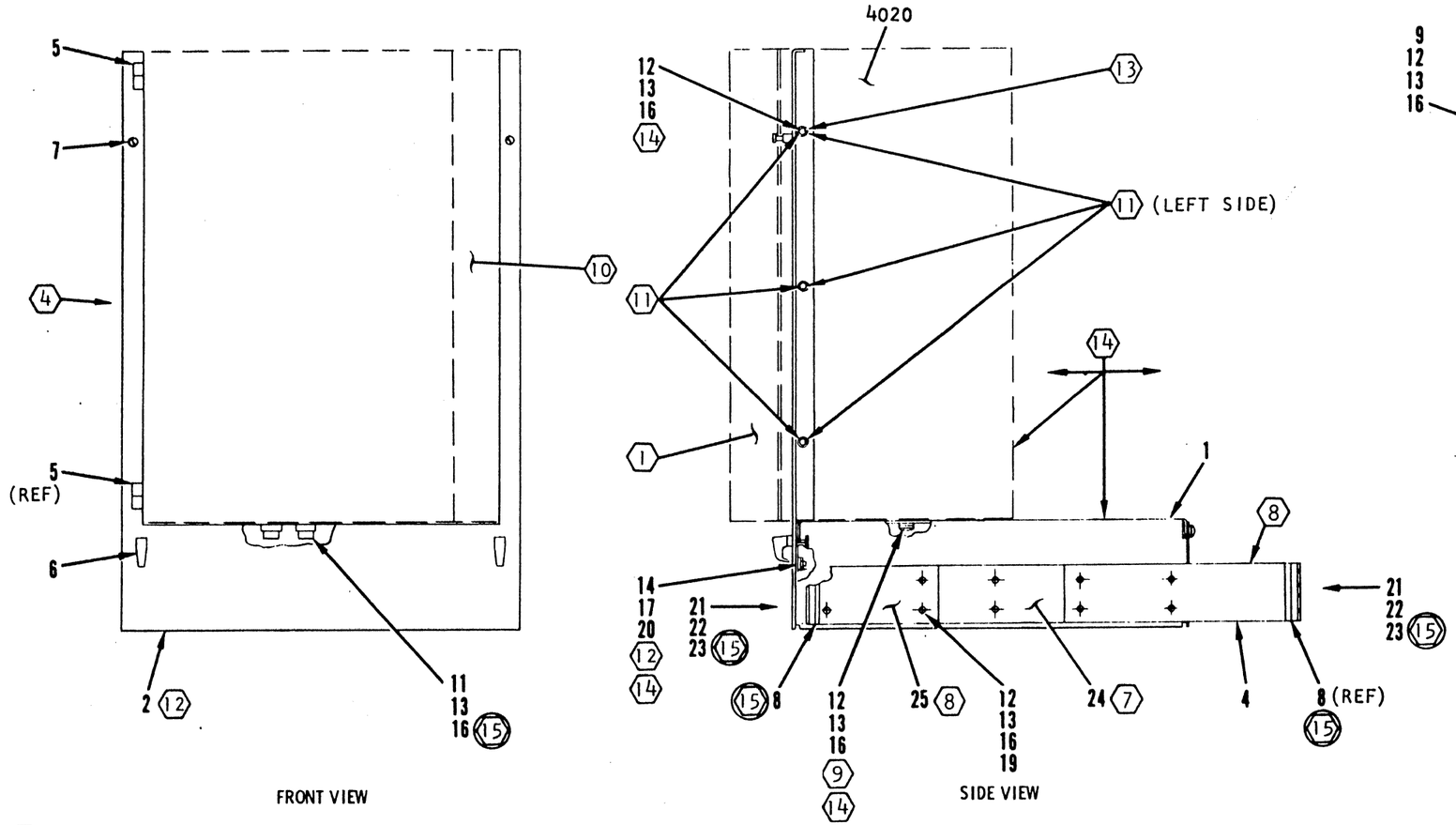
ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY -7	QTY -14	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	175431-0242	Screw, pan hd, 8-32 x 5/16	4	4	6-1/11		
2	175431-0245	Screw, pan hd, 8-32 x 1/2	50	50	6-1/12		
3	70077-0678	Washer, flat, no. 8	54	54	6-1/13		
4	70077-0674	Washer, flat, no. 6	7	7	6-1/14		
5	70077-0173	Washer, flat, no. 4	7	7	6-1/15		
6	166497-2040	Washer, split lock, no. 8	54	54	6-1/16		
7	166497-2030	Washer, split lock, no. 6	7	7	6-1/17		
8	166497-2020	Washer, split lock, no. 4	7	7	6-1/18		
9	7074-0280	Nut, hex, no. 8	36	36	6-1/19		
10	7074-0268	Nut, hex, no. 6	7	7	6-1/20		
11	175431-1263	Screw, pan hd, 10-32 x 1/2	16	16	6-1/21		
12	70077-0681	Washer, flat, no. 10	16	16	6-1/22		
13	166497-2050	Washer, split lock, no. 10	16	16	6-1/23		

Table 6-7. Parts List for the 12-480-2 Fixed Rackmounting Kit (Sheet 1 of 2)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	545360-0022	Kit, fix mtg, 4020A (1/2-inch)	1			
2	545360-0025	Kit, fix mtg, 4020A (1-inch)	1			
3	545360	Installation Dwg	1	6-2		
4	518254-0001	Bracket, mounting	1	6-2/1		
5	518254-0002	Bracket, mounting	1	6-2/2		
6	518255	Nut, strip	2	6-2/3		
7	518413	Bracket, mtg, power input	1	6-2/4		
8	14050-42750	Screw	18	6-2/5		
9	166497-2043	Washer, split lock, no. 8	18	6-2/9		
10	70077-0638	Washer	18	6-2/12		
11	14050-3425	Screw (used on 545360-0022)	20	6-2/6		
12	14050-3425	Screw (used on 545360-0025)	24			
13	7129-0002	Nut (used on 545360-0022)	20	6-2/15		
14	7129-0002	Nut (used on 545360-0025)	24			
15	14050-2625	Screw, pan hd, 4-40 x 0.25	4	6-2/7		
16	14050-2645	Screw, pan hd, 4-40 x 0.38	3	6-2/8		
17	166497-2023	Washer, split lock, no. 4	7	6-2/11		
18	70077-0133	Washer, flat, no. 4	7	6-2/14		
19	7074-0244	Nut, hex, 4-40	3	6-2/16		

Table 6-7. Parts List for the 12-480-2 Fixed Rackmounting Kit (Sheet 2 of 2)

ITEM NO.	B&H PART NO.	DESCRIPTION 0 1 2 3 4 5	QTY	FIG./INDEX OR REF SYM	MFR CODE	MFR OR MIL PART NO.
1	84071-0002	Sealing Compound, Loctite "C"	A/R	6-2/10		
2	519636	Bracket, mtg, bnc panel	2	6-2/13		
3	519637	Panel Assembly, bnc (used on 545360-0022)	1	6-2/17		
4	519637	Panel Assembly, bnc (used on 545360-0025)	2			
5	519638	Plate	2			
6	476108	Panel	1			
7	175431-0242	Screw	4			
8	70077-0678	Washer, flat, no. 8	4			
9	166497-2040	Washer, lock, no. 8	4			
10	155527-0001	Ferrule, grounding	14			
11	7127-0002	Terminal, lug	16			
12	126732-0031	Connector, bnc	16	A3J1-A3J16		



FRONT VIEW

SIDE VIEW

REAR VIEW

(8) ATTACH SLIDE MOUNTING BRACKETS 518253 AND 518616-0001 TO THE SLIDES. SCREW HEADS ARE INSIDE THE SLIDE WITH WASHERS AND NUTS TOWARD THE CABINET WALL. ADJUST LENGTH OVER MOUNTING BRACKETS TO FIT CABINET.

(7) ATTACH SLIDES 518616-0018 TO TRANSPORT MOUNTING CHASSIS 518251. SCREW HEADS ARE ON THE INSIDE OF THE SLIDES, WASHERS AND NUTS ARE ON THE INSIDE OF THE MOUNTING CHASSIS.

6. SECURE POWER SUPPLY IN ITS PROPER PLACE.

(5) INSTALL POWER INPUT ASSEMBLY ON THE TOP SIDE OF THE FLOOR OF THE TRANSPORT CASE.

(4) REMOVE POWER INPUT ASSEMBLY 518219.

3. SLIDE POWER SUPPLY **524536** , AS FAR TO THE REAR AS CABLING PERMITS.

2. REMOVE SKIDS 476062 AND BASE COVER 518682 FROM BOTTOM OF TRANSPORT.

(1) REMOVE DUST COVER 476008.

NOTES: UNLESS OTHERWISE SPECIFIED.

(15) RACK OR CABINET MOUNTING HARDWARE, FURNISHED LOOSE.

(14) ADJUST POSITION OF TRANSPORT ON MOUNTING CHASSIS SO THAT ALL HARDWARE, ITEMS 12, 13, 16, 14, 17, AND 20 MAY BE TIGHTENED WITHOUT DISTORTING CHASSIS COVER.

(13) HOLD NUT BAR IN PLACE, REMOVE UPPER SCREW, MOVE COVER INTO PLACE AND INSTALL HARDWARE ITEMS 12, 13, AND 16.

(12) INSTALL CHASSIS 518252, BUT LEAVE LOWER HARDWARE LOOSE.

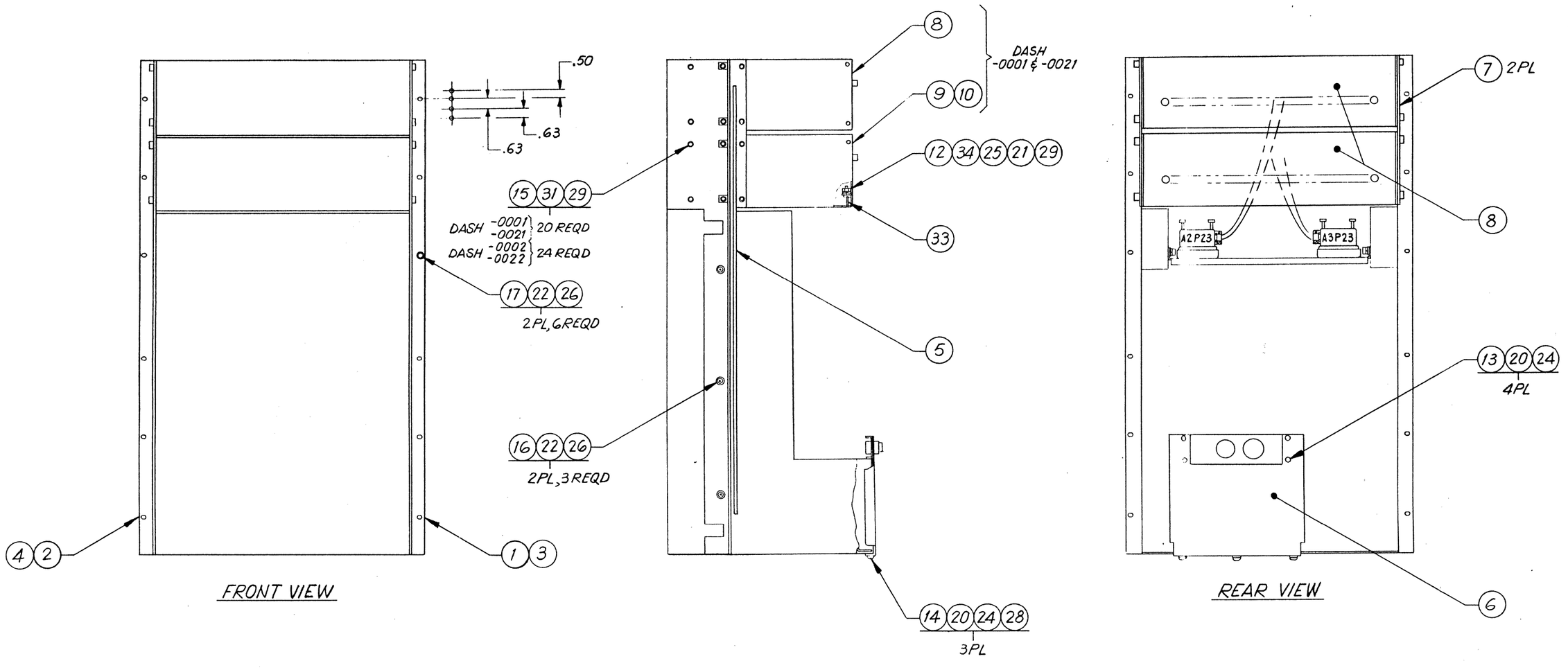
(11) REMOVE 3 SCREWS FROM THE LEFT SIDE OF THE TRANSPORT AND THE 2 LOWER SCREWS FROM THE RIGHT SIDE.

(10) REMOVE CONTROL PANEL 476049 AND CONTROL LOGIC AND BRACKET ASSEMBLY 476077, TO EXPOSE INTERNAL NUT BAR.

(9) MOUNT THE TAPE TRANSPORT ON THE TRANSPORT MOUNTING CHASSIS 518251. INSTALL SCREW HARDWARE BUT LEAVE IT LOOSE.

D-518778-B (REF)

Figure 6-1. Installation Drawing and Mounting Instructions, Slide Rackmount



D-545360-X (REF)

Figure 6-2. Installation Drawing and Mounting Instructions, Fixed Rackmount

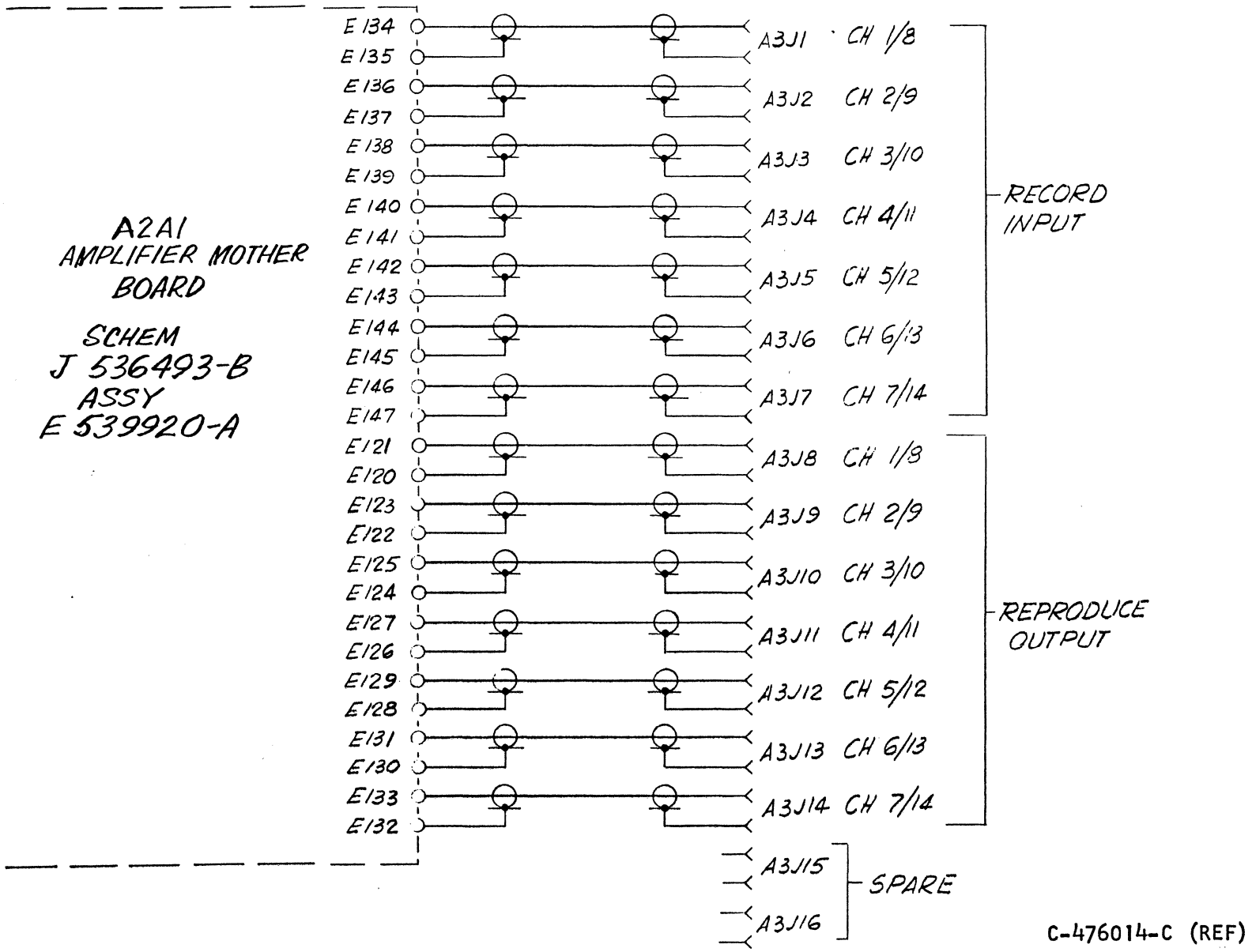


Figure 6-3. Cabling Diagram, Rackmount to Mother Board